SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXXIII
NUMBER 2143

★ NEW YORK, JANUARY 27, 1917 ★

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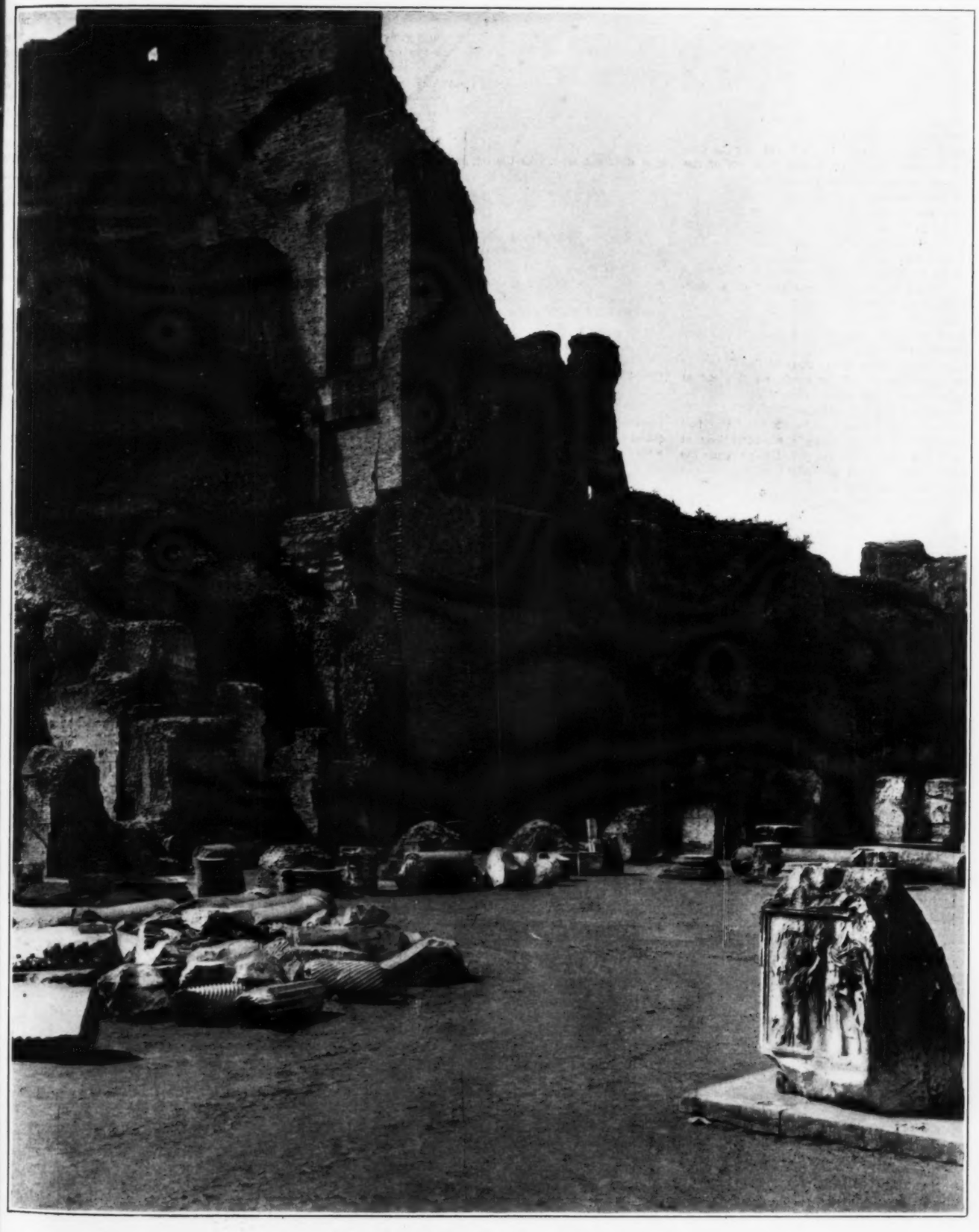


Remains of the Imperial Tribunal, at Rome.

NEW EXCAVATIONS ON THE PALATINE.—[See page 56.]

A Theory of Terrestrial Volcanoes*

and the Geography of the Moon

By Stanislaus Meunier, Museum of Natural History, Paris

LONG-CONTINUED studies have led me to develop a new theory in regard to the phenomenon of volcanoes, a theory which, it seems to me, harmonizes with the best-established facts of geo-dynamics, differing therein from all preceding theories. A necessary sequel has been a study of the consequences to which the theory leads as regards the future of eruptive activity itself.

In making that study, I adopted the method of the mathematician, who proceeds to the solution of a given problem by varying the elements of the problem in order to discover the corresponding special cases. Accordingly I have assumed hypotheses regarding the geologic consequences that result from modifying the variables of the problem. I shall not try to conceal the satisfaction I felt on finding that one of the suppositions examined explains completely the circumstances of lunar economy.

The discussion involves three main consequences:

1.—It tightens in an unexpected manner the geologic bonds existing between the earth and the moon. This result is so conformable to the ingenious cosmologic conception of Laplace as to constitute a veritable confirmation of it, by furnishing definite proof of the similarity of the physical constitution of our globe and its satellite, as well as of the identity of their behavior in the course of sidereal evolution, in which they represent two successive stages.

2.—In the second place, the relation of the history of the moon to the history of the earth, so different at first sight as regards the phenomena of volcanism, includes the verification, the tangible verification so to speak, of the eruptive theory, although the latter had been established on purely geologic considerations at the very moment when I felt compelled to postpone the selenographic study, which seemed to require a combination of special conditions.

3.—Finally, by means of a correlation which *a priori* seemed hazardous, my results furnish a new support for that great chapter of science which is yet far from being fully understood, but which nevertheless has so often and so strongly fascinated me from the very beginning of my career, namely, the chapter of comparative geology.

This may seem a bold programme, and in laying it before the reader I feel it may arouse a certain skepticism. Nevertheless I feel confident that my undertaking will benefit the work on which I am engaged, namely, the building up of a body of arguments which will naturally group themselves into one of the chapters of the geologic harmonies of the physical universe.

In order readily to understand the bearing of the statements just made, it is necessary to call briefly to mind the nature of the proposed volcanic theory and what, in my opinion, it is capable of explaining.

According to this theory, *volcanic activity* is a normal and therefore inevitable result of the regular evolution of our globe. It therefore determines, on the one hand, all the details of the earth's constitution, that is to say, of its *anatomy*, and, on the other, all the details of its activity, that is to say, of its *physiology*. According to this theory, also, volcanic activity is a natural and frequent result of the formation of mountains, being in fact its epiphenomenon, so to speak.

We have to recall the circumstances accompanying the beginning of planetary history and to assume, with Laplace, that the earth is but a drop of the chaotic substance separated from the sun, like the other globules of the same nature, which, before or after it, have taken on the condition of autonomous bodies. The sun represents the enormous residue of primordial matter from which these successive products were derived.

The globular form assumed by the mass that was to be our planet results from the dominant property possessed by the molecules of all mobile matter to attract one another and thus to become grouped around their common center of gravity. Laplace has shown how this attraction causes the heating of the whole mass and at the same time its general movement of rotation around its own axis. We need add nothing to the conception of the author of the "Exposition du Système du Monde in order to understand in outline the successive stages of our globe, all due to the spontaneous cooling caused by its position in space, the temperature of which is far below that of the earth itself.

The first effect of cooling was to deprive the chaotic matter of any homogeneity which it might have had at the start, the result being a solid crust forming a partition between the uncooled fluids that constitute the nucleus of the globe and the far less dense fluids forming the ocean and the atmosphere.

Ever since the crust began to form and grow thicker by additions on the inside, owing to the progressive solidification of the nucleus, it has tended to accommodate itself to the ever-changing conditions arising from the steady diminution in volume of the enclosed mass. While that mass contracts during cooling without changing its form, which remains spherical while its diameter decreases, the crust, which is not contractile, responds in a different way. As the support furnished by the fluid nucleus is withdrawn because of its contraction, the crust has to follow it and hence becomes increasingly corrugated, with attendant faults (geoclases) and tangential thrusts.

This is the well-known cause of topographic relief, the cause of continents and oceanic basins. The water, instead of covering the globe as a uniform sheet, has collected in the oceanic basins, to which, by a ceaseless circulation, it always returns after falling as rain and flowing over the land as storm water and running water—aside from the large amount that seeps into the ground, of which we will speak later on.

Without entering into details which every one knows, I will merely add, for the sake of clearness, that the deformations of the earth's crust, constantly diminishing the diameter of the planet, consist essentially in the transformation of a centripetal action into a tangential compression, as is shown by the great mountain ranges, whose natural escarpments so often and so clearly reveal to us the internal structure. In these mountain ranges beds of a great variety of rocks are seen resting one on the other, which may be correlated with the strata of the plains, but which have been modified in their mineral composition by metamorphism and in their relative position by orogenic forces.

As regards the last-mentioned point, the essential fact is that geologically old strata commonly rest on geologically younger strata, which is exactly the reverse of what prevails in undisturbed sedimentary regions. When, for example, we climb the Alps we first pass over very recent beds, such as the Tertiary conglomerates of the Righi, next over Mesozoic deposits, such as the Cretaceous and Jurassic marbles of Mount Pilatus, next over Paleozoic sediments, such as the Carboniferous shales of the Moëde, etc., and only when we arrive at the top do we find the primitive rocks, such as the gneisses of the Jungfrau.

There can be no doubt that these strata were pushed along nearly horizontal planes of fracture, with the result that they now occupy a much smaller area than they did originally, while their thickness has increased by superposition, as has just been pointed out. Thus there has been a transfer of deep-seated material over younger strata. It is necessary to recall this commonplace notion, because it suffices to give us the viewpoint needed for the present subject as regards everything relating to the structure of mountain ranges, which for that matter varies widely.

Summarizing this first point, we see that the spontaneous cooling of the globe gives rise to a tangential compression of the crust, which at any given moment is too wide for its contents, and that this is the sole cause of the characteristic superpositions observed in mountains.

This, however, does not yet suffice to explain completely the origin of mountains, and it is proper to note that the process just described is strictly confined to the underground regions. In order that a mountain may be formed another thing is necessary: the block that has been compressed in the underground region has to be raised by tangential reactions, causing a protuberance that rises above the general surface of the planet. The gigantic tuberosity of Thibet, in the heart of the Asiatic continent, is a type.

Space will not permit of presenting the arguments which prove that the compression and transfer on the incline planes of geoclases can take place only in a certain portion of the crust. The deeper portions are still too hot to admit of the production and maintenance of gliding planes in their plastic substance, while in the outer parts the porosity and compressibility of the rocks constituting the substratum, opposing their inertia to the propagation of vibrations, protect the superficial strata against excessive mechanical shocks, which would constitute an insuperable obstacle to the development of external phenomena, such as the manifestations of organic life.

Without dwelling on this subject let us note merely that the mechanical deformations of the crust are not the only inevitable consequences of the spontaneous cooling of the globe.

Another fact of equal importance, and without which volcanism would be impossible, develops parallel with the first. We have already noted that the lowering of the surface temperature has led to the condensation of water, the fall of rain, and the development of rivers whose waters accumulate in the ocean basins. Part of the water penetrates into the crust not only by constant infiltration but by the burial of wet sediments under later sediments, whereby water and other volatizable matter are imprisoned in the solid mass at constantly increasing depths and are incorporated in a large part of the thickness of the crust.

This being premised, we must next observe that the over-thrusting just described, whereby the rock masses are superposed (often in inverted order) acquires a new meaning from the very presence of water. The water-soaked zone thus forms an envelope around the deeper zone which is as yet too hot to admit the entrance of water. At many points the orogenic compression, taking advantage of geoclases, carries the waterless strata over less hot water-soaked strata. The latter are thus subjected to *reheating* under circumstances which are particularly interesting. We know the effects likely to be produced by such reheating under the influence of water incorporated in deep-buried rock masses having no communication with the surface. On this point Sénarmont has made experiments of which I am unable for lack of space to mention more than the results. He has shown that in *superheated* water, as he called it, that is to say, water subjected to a temperature of several hundred degrees in a closed vessel, the ordinary rocks take on all the characters of metamorphic and volcanic rocks. The water, strongly compressed and having reached the condition when it assumes the mineralizing function, becomes incorporated with the rock particles, and thus in the state of occlusion it endows them with the expansive property.

Suppose next that a mass of rocks thus charged with occluded water under high pressure is put into communication with the atmosphere through a fissure, for example. The occluded vapor, no longer held back by a resistance equal to its expansive force, will seek to attain equilibrium of pressure with the atmosphere; it will issue from its confinement and carry with it the rock magma in which it is dissolved, ejecting it through the vent, and thus will produce the volcanic phenomena in all its details. Without attempting any detailed proof, let us note that this line of reasoning explains all the incidents of the volcanic phenomenon, from the ejection of ashes, vesicular pumice, and scoriæ to the rise and overflow of lava and even the formation and the action of fumaroles.

Volcanism as a whole, as has just been found to be the case with seismism, is an epiphenomenon of the production of mountains. This is why intrusions of igneous rocks in all their forms play such a prominent part in all complete mountain ranges.

Summarizing, we may say that eruption results from the collaboration of two processes, seemingly quite unrelated:

1. The *progressive penetration of water* and other volatile substances to a depth within the earth's crust which is strictly dependent at every instant on the degree of spontaneous cooling.

2. The *tangential compression of the rocks*, due to the contraction of the nucleus and also to the tendency of the crust to founder into deeper and deeper regions where the horizontal space grows narrower and narrower.

Thus the crust of our planet forms a kind of weaver's loom, producing the volcanic tissue, the *warp* being represented by the descending network of threads of water, while the *woof* is represented by the tangential network of heated material, due to the orogenic superposition of intrusive masses over water-soaked sediments.

Harking back to the point from which we started, we may here adopt the practice of the mathematician who devotes himself to the discussion of a given proble

*Translated from the French by Arthur L. Day, and communicated by him to the Washington Academy of Sciences. Republished from the *Journal* of the Academy.

We may inquire what special results would follow from modifying one or the other of the two factors of the eruptive phenomenon.

Let us note, first of all, that the volcanic phenomenon could only have appeared after a long evolution of the terrestrial globe, because it requires a crust, and not only this but the superposition of two concentric zones: the one deep down and very hot, the other at less depth, impregnated with water and of moderate temperature.

However, to dwell on this point would be to enter into the domain of comparative geology. Suffice it to say that from the moment when the crust was formed, and long before, eruptions had taken place, different no doubt from, but yet comparable in certain respects and belonging to, the class now represented by the majestic spectacle of the solar eruptions.

Hervé Faye recently established the synthetic theory of the sunspots and of the red protuberances accompanying them, and showed that these phenomena represent an incessant radial circulation of the material constituting the epidemic zone of the sun; we might almost say the *cortical* zone, for the photosphere represents as it were a rudimentary crust, situated, like the earth's crust, between the atmosphere and the nucleus, but as yet in an unstable condition because of its extreme thinness. It exhibits one of the stages through which the lithosphere of our own globe must necessarily have passed.

The circulation, which (like the circulation of water in the earth's organism) is radial, results from conditions no longer found on our globe, conditions due to the extreme mobility of all the solar elements. Faye notes the production of whirlwinds in the sidereal mass, and he does not hesitate to compare their course and cause to those of the eddies in rapid rivers. The solar eddies, like those of rivers, carry into the depths of the moving fluid the material derived from the peripheral zone, and their descent, though effected in quite a different way, reminds us of the progressive soaking of the rocks by water, for, like this soaking, it results in producing the mechanical force that is the cause of eruption. Once this relatively cool material derived from the solar surface has been carried to the proper depth, it is heated, expands, and yields to an enormous pressure tending to shoot it out into the atmosphere, where it forms the rose-colored flames. Evidently it cannot burst forth in this way without carrying with it material derived from relatively lesser depths, especially from the photosphere. This process shows that the solar explosion is an agent for the mixing of substances which by the diversity of their physical properties seemed destined to be forever separated, just as happens in the case of volcanic eruptions on the earth.

We are not yet in a position to give an exact account of the details exhibited by the volcanic phenomenon at its first appearance, as soon as the necessary conditions were realized on our globe. However, observations of a purely geologic nature show that the upheavals of rocks since the oldest sedimentary epochs are so closely comparable to the work of modern eruptions as to suggest that the appearance of volcanoes was virtually instantaneous. To gain a clearer view on this point we should have to consider successively the consequences that would flow from the various possible combinations of temperature distribution along one and the same terrestrial radius, under the complications that would arise from the fact of the freezing of water at the surface and also at greater and greater depths. We should also have to make the same inquiry as regards the distribution of the water soaking into the deep strata, which would necessarily carry with it the zone of volcanic activity. All these subjects, and various other subjects besides, suggest discussions, some of which promise definite conclusions. It may suffice here to suggest them, while awaiting fuller data from the progress of science. We can merely attempt to set up a few hypotheses as regards the future of eruptive activity.

First of all, we may turn our attention to the relations between the cooling process and the stock of infiltrated water. The quantity of water available in the superficial regions of the earth is evidently limited, and the progress of cooling constantly tends to diminish the amount of water in seas, lakes, air, and even in the interstices of rocks. The tentative estimates made on this point at various times, by totally different methods, have invariably led to the conclusion that the quantity of water already absorbed by the crust is several times larger than the total volume of water still remaining on the surface in the liquid state; and that this remainder is only a small fraction of the amount that would be needed to saturate the entire crust to the degree of humidity observed in moist rocks, described by the expressive term of *quarry-water*. A time will come, therefore, when the earth will be completely dried up, because all its water will have disappeared, by infiltration in the beds of rock.

On the other hand the globe, growing cooler all the time, will some day arrive at a state of equilibrium with the temperature of space. Thus the two factors of volcanism will disappear independently of each other, and not necessarily at one and the same time.

Several suppositions may be based on this consideration. Suppose, first of all, that the time necessary for the complete absorption of the water by the crust is exactly equal to the time required for the complete cooling of the globe. In that case it may be that the volcanic phenomenon may gradually fade away and disappear without any important modification of the exterior of the planet.

Suppose, in the second place, that the quantity of water were much larger than it actually is on the earth. In that case, when the cooling has been completed, the whole planet will still be impregnated with water, a surplus of which will even remain on the surface. Long before that time, of course, the water will be frozen, and ice will be a rock like the other petrographic species.

Let us, however, take the opposite case, supposing that the quantity of water is insufficient to moisten the entire rock mass during the process of cooling. In that case the volume of the seas and of all the other liquid water bodies of the surface will diminish until it disappears, and the globe will be completely dried up while still warm. But—and this is the essential point—the drying up will not necessarily cause the disappearance of the volcanic phenomenon. That phenomenon is not a superficial reaction; on the contrary, its focus is situated at a great depth, and that depth is constantly increasing as the absorption of liquid water continues. Thus the conditions necessary for an eruption may continue long after the drying of the surface is completed. For example, the water that active volcanoes emit nowadays no doubt represents a contribution from the ocean going back to very ancient geologic periods. The orogenic superposition of moist subterranean regions by hot rocks driven tangentially over the roof of the great geoclases may continue for long geologic periods, which means that water of impregnation will continue to be occluded in the substance of ancient sediments, which will take advantage of the smallest fissure communicating with the upper, less dense regions to inject themselves into them by expansion. The feebleness of the atmospheic pressure, dwindling little by little to zero, will increase the number and energy, perhaps also the volume, of the outbursts, and will especially affect the *relief* of the material ejected upon the surface as cones of lapilli and ashes, needles, chaotic accumulations of scoriae, and lava flows. In addition the superficial water, except the volcanic rains, having little by little disappeared, erosion, formerly so active, will cease, and consequently the products of eruption will persist without much alteration. Meantime the centers of eruption will constantly increase in number, until they may eventually cover the entire surface of the planet. By a singular contrast the planet destined to perish by progressive cooling will don as its final garment a shroud woven by volcanic energy.

The picture thus drawn of the effects of a prolongation of volcanic activity after the complete absorption of the surface water is closely analogous to the most essential features of lunar geography. Without going into detail, I will content myself with expressing my satisfaction on finding that the volcanic theory outlined at the beginning of this article is completely borne out by an object-lesson, the moon.

Let us suppose that this theory really expresses the facts, and that the earth at the dawn of the Tertiary epoch had reached a condition where all its surface water had been absorbed, while the volcanic activity was still in full blast. It is easy to see what would have happened. Volcanic eruptions would have continued, and their products would have been spread over the surface; but there would have been this essential difference, the volcanic outflows would no longer have been exposed to the destructive action of rain and seas. They would have accumulated side by side without perceptible change. To form an idea of the morphologic effect on the earth's surface it may suffice to point out that the previous sediments would have disappeared, more or less completely, beneath this sheet of volcanic material.

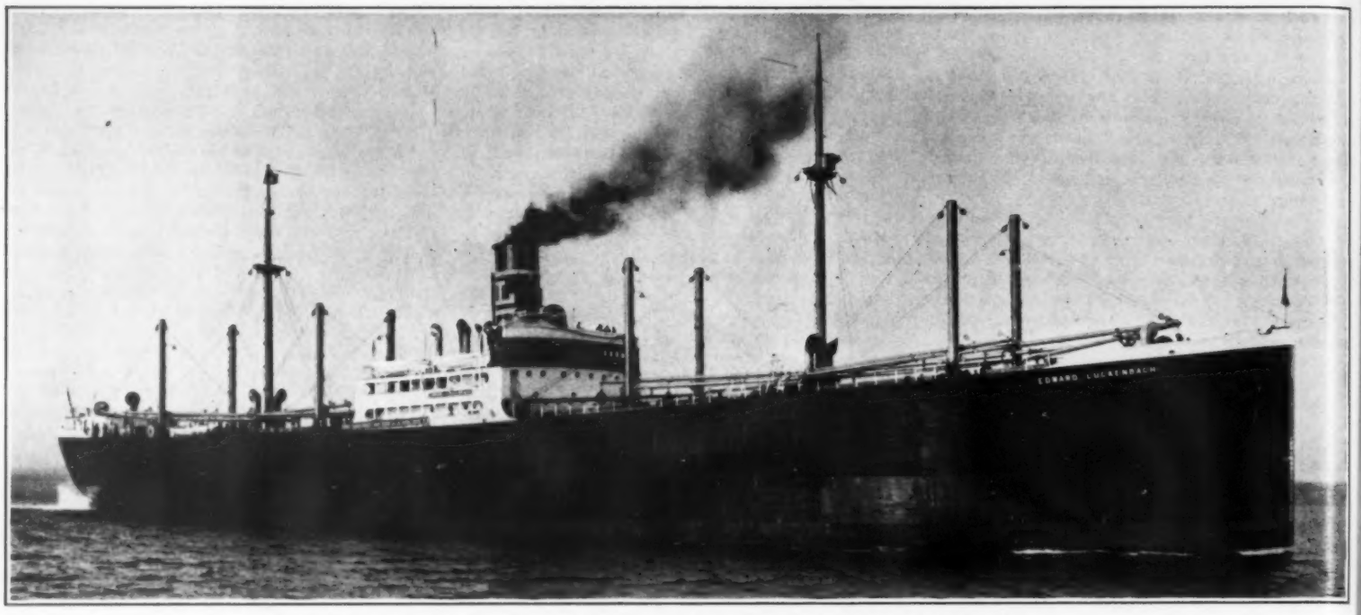
The importance of this fact will be appreciated if we cast a glimpse at the condition in which Europe, for example, would be if all the eruptive formations poured out since the beginning of Tertiary time had remained intact, side by side.

From Iceland, with Hecla and its companions, from the British Isles, with Skye, the Hebrides, the Faroes, and Ireland, with Antrim, to the Mediterranean Basin, with Sicily, continental Italy, Elba, and Santorin, the Tertiary and Quaternary eruptive centers follow one another without any wide gaps. All central Europe was volcanic: Hungary and Transylvania are dappled with trachytes and rhyolites; Bohemia rests on vast and highly varied outflows; in the Höhgau, basalts are associated with phonolites; the Siebengebirge around Bonn, the Drachenfels, Mount Meissner in Hesse, the so-called Kaiserstuhl region in the Breisgau, the vicinity of Mainz and of Cassel, the Eifel, and above all the vicinity of the Laacher See, are made up of outflows, and their analogues occur throughout the central plateau of France, in Puy-de-Dôme, Mont-Dore, Cantal, Velay and Vivarais, and also in Catalonia, near Olot and Castel-Follit. The Carpathians, the Caucasus, the region of the Great Ararat, and Allagöz belong to the list, which we may here bring to a close, long before it is complete.

If we remember that the other parts of the world are not less rich in volcanic manifestations than Europe, and if we recall that the ocean basins also are dotted with them—the Indian Ocean as well as the Pacific and Atlantic showing everywhere eruptive centers, most of them as yet imperfectly known; if, finally, we remember that in the absence of rain and wind the pulverulent ejections of the volcanoes would cover the earth's surface around every fiery vent in such a way as to mask all the anterior formations under this volcanic snow, we shall arrive at the conclusion that the earth would exhibit all the characteristics shown so clearly and sharply on the disk of the moon. So far as I am aware, this is the first time, since observers have been busy with the lunar problem, that its explanation crops out of itself as a logical consequence of a hypothesis elaborated entirely independent of any astronomic considerations.

In conclusion I may be allowed to dwell on the last remark, which suggests a reflection in the line of comparative geology: That science has grown up on the common frontier of geology (or science of the earth) and physical astronomy (or science of the heavens), exactly as comparative anatomy has grown upon the common frontier of human anatomy (or science of the human body) and animal anatomy (or science of the bodies of animals). The resemblance extends even to the increase of knowledge and to the philosophic generalizations by which both of the compared sciences benefit. The great general laws of animal organization, revealed to us by the science of comparative anatomy, are an earnest of those which we may discover in regard to the economy of the celestial bodies as a result of the progress of comparative geology. We know that astronomy proceeds not only by purely morphologic investigations of the celestial bodies, but that several other means of study have been opened to it successively by physics and chemistry; spectroscopy, which is based on the prismatic analysis of the light emanating from the heavenly bodies or reflected by them, has demonstrated the chemical unity of the heavens, just as telescopy had shown their mechanical co-ordination. On the other hand, through a piece of good luck which no one could have foreseen or hoped for, bits of substance derived from the cosmic regions and precipitated on our planet in the form of meteorites, have supplemented the spectroscopic evidence by a large number of extra-terrestrial minerals, enabling still closer comparisons to be made. A geologic relationship has thus been revealed, and the legitimacy of synthetic suppositions of the widest scope can now no longer be called in question. It does seem as if we were now in position to say that all conceptions that hold that the physical constitution of heavenly bodies differs from the constitution of the earth are erroneous. I may be permitted to express the hope that the present paper may serve to reinforce this conclusion by showing that the moon, which has inspired so many hypotheses, in reality presents morphologic features that are not only compatible with those of the earth, but also harmonize completely with the proposed volcanologic theory of the earth, an agreement as neat as it was unforeseen. It furnishes the most valuable confirmation of that theory, while in return it receives not less decisive confirmation from geologic studies.

It is a rare pleasure to find such complete agreement between two lines of study which at first sight seem so unrelated. I may even be permitted to express a sort of gratitude, somewhat superstitious perhaps, to the Unknown Cause which reveals to our minds some of the harmonies, hitherto so jealously hidden, of the natural mechanism. A glimpse of these harmonies sometimes bursts on the mind so suddenly that one has the feeling of an astonished spectator rather than of an originator.



A fine type of the new commercial cargo carriers now being built in the United States.

A Modern Cargo Vessel

One of the Recent Additions to Our Commercial Fleet

ONE of the important results of the war has been its effect on the commerce of the world, for the withdrawal of the great fleet of German vessels that infested every port, and the sinking of hundreds of British cargo carriers, has created a great shortage of ships; while on the other hand the needs of the allies for immense quantities of supplies and materials has created an increased demand for transportation facilities that has been difficult to meet. Every harbor has been scoured for every kind of a craft that would float, and even our Great Lakes contributed many vessels that had been laid up for years on account of lack of business to keep them employed.

To make up this lack of transportation facilities every available shipyard has been overwhelmed with orders, and as those of Germany are unavailable, and the allied countries are too busy with government work to lend much assistance, most of the pressure has fallen to the United States, as it is the only country that has the yards and can supply the necessary materials in the required quantities. Not only have all of our existing shipyards been operated to their limit, but many new yards have been established, several of which have taken up the building of wooden vessels, a construction that had been thought to be obsolete except under special circumstances.

While a considerable proportion of the vessels building have been for foreign owners, notably the Norwegians, large additions are being made to the American fleets of mercantile vessels, and in building these ships all the science of the naval architect has been requisitioned to produce the best and the most efficient vessels that can be obtained. A notable example of these new American commerce carriers is shown in the illustration on this page, which combines all the latest ideas in cargo carrying vessels. This ship, which is of the shelter deck type, is a very handsome craft of 8,151 gross tonnage, with a carrying capacity of 12,250 tons, or 584,270 cubic feet in the cargo holds. Her length over all is 456 feet 5 inches; breadth molded, 57 feet, and depth molded to the shelter deck, 41 feet 6 inches. The load draught is 31 feet 8 inches.

One noticeable novelty is the modified cruiser stern that gives it a distinctive character, and another feature is the adoption of eight king posts for working the cargo booms, in addition to those mounted on the two masts which the vessel carries. Each of these king posts is fitted with two five-ton booms; the foremast has one thirty-ton and four five-ton booms, and the mainmast has one twenty-ton boom and four five-ton booms. These booms are served by twenty-four deck winches, conveniently distributed; and this equipment, together with eight large hatches, enables cargo to be handled very expeditiously and economically.

The propelling machinery, which is all located compactly amidships, consists of a steam-driven turbine that delivers 4,000 horse-power to the shaft, but is capable of giving an additional 500 horse-power when necessary. This turbine operates at a speed of about 3,300 revolutions a minute when working economically; but as this is too great for the best results at the propeller, a double stage reduction gear is introduced, so that the propeller, which is 19 feet in diameter, with a pitch of 16 feet, is driven at ninety revolutions a minute, which gave the vessel a speed of fourteen knots on her trial trip. Oil fuel is used, and is carried in the double bottoms and forward and after peak tanks.

Unusually attractive quarters for the officers and engineers are provided in the amidship deck-house, and the firemen and crew are located in the after deck-house, insuring the comfort of the entire ship's company on long voyages. Entirely inclosing the navigating bridge is a feature for promoting the comfort of the watch officers that is being rapidly adopted on modern ships.

The ventilation of the holds has been given particular attention, and both these and the 'tween deck cargo spaces have a natural supply of air through cowl ventilators, and there is also a mechanical exhaust induced by four electrically driven exhaust fans.

Taken altogether this ship is a very handsome craft of distinctive appearance and individuality, and a most creditable addition to our fleet of modern freight carriers. The present vessel is the first of five similar ships now being built for the same firm of owners.

The Typha Plant—A Substitute for Cotton

A WRITER in *Le Matin*, Paris, discusses the question of a substitute for cotton, which is so largely used at the present time for war purposes in addition to the great annual consumption for industrial uses. It need not be said that any means by which heavy importations could be reduced would be of great economic importance. One of these would be to cultivate cotton in the French colonies and especially in Africa, but this has not as yet been systematically carried on. Another method is pointed out by the author, and this relates to the use of a plant which is widely disseminated. In fact the plant known as *typha* grows almost in any place where there is water, such as ponds, marshes or water courses, and the general cultivation of this plant would give a good utilization of large areas of unproductive ground. It is an easy matter to cultivate the plant, for it is grown from seed and also by dividing up the root, which resembles that of the iris, and this latter is in fact the easiest method of planting. The root is always planted in watery grounds. The plant bears a pod which opens when ripe and scatters its contents to the winds, and this substance in fact has some resemblance to cotton; upon analysis it is seen to be composed of almost pure cellulose. This plant is not unknown in other countries, and it is said that efforts are being made in different places to make use of this valuable material in order to replace cotton, wool and jute. Countries like those of Europe which do not produce cotton would have an enormous advantage in using the proposed substitute, provided, of course, it is really able to replace cotton as a fabric, which, however, is not yet proved. But as to its use as a source of cellulose there would seem to be no doubt as to its value for such purposes. Another use would of course be for the paper industry. As will be seen, the question is a most important one, both for the war as well as for industrial uses.

Sterilizing and Filtering Drinking Water

MESSRS. FOURNEAU and Lemaland treat of improved methods of sterilizing water either for ordinary or war use. As to the method commonly employed, i. e., chlorine, iodine or permanganate, the first and second sterilize water but do not clarify it, hence it must be filtered beforehand. But with clear water, iodine and chlorine are good and rapid. The French army now uses a large amount of chlorine water for this purpose. The permanganate process involves the use of permanganate and then hyposulphate of soda, and is good for troubled and even muddy water, but the need of an after filtering makes this method rarer. The authors wish to make this process more practical for use under all conditions, and mention their new filter, which serves for the above or for water which is simply clarified by ferrous salts or alum. Two types are made at present, the first one being designed as a pocket filter, and in eight minutes it can filter a quart of water after treatment by permanganate. The second or large size holds three gallons and filters two gallons in thirty-five minutes. As to the pocket size, it is of aluminium and resembles a telescoping cup, being in three pieces. The bottom has a hole, and in the cup is fitted a specially made sterilized and compressed cotton washer against the bottom, and this acts as a filter under the most approved conditions. When the cup is telescoped, it is stowed in a metal box, which also holds two small boxes, one with forty tablets of permanganate and a second with the same number of hyposulphite. In a separate long tubular box are held the cotton washers, which are of smaller size than the diameter of the cup. The large size filter is a canvas bucket with perforated metal bottom, above which rises a conical false bottom, carrying a receptacle for laying in a cotton washer. Screwing a cap on the washer holder prevents the water from running out and makes a bucket of the usual kind. Another cap, carrying a hose, can be screwed on, so as to deliver water through the hose, which is often useful.

Old English Weathervanes

Some Curious Mediæval Finial Decorations

THERE is one subject of perennial and absorbing interest, about which more has been said and written even than about the war. I speak of the weather.

It would be a hitherto unknown kind of weather that succeeded in pleasing everybody, but we have for quite a number of years past been experiencing the sort, or rather sorts, of weather which, so far as my information goes, satisfies no one.

I have written this prefatory matter for the purpose of leading up to the subject of weathercocks, an interesting one on which I chance to possess much curious lore.

Really, it was the Coventry new "Municipal Buildings," as they say nowadays, "Town Hall" being too

The large figure of St. Michael on the spire of the Abbey at Mont St. Michel, in Normandy.

homely a kind of language to use in an era in which ministers of the crown return answers in Parliament "in the negative" or "in the affirmative," as the case may be—instead of saying plain "no" or "yes"—which gave me thoughts of weathercocks. Though if it be indeed a weathervane on the chief tower of those ornate and costly buildings, or whether it is just an ornamental finial, I do not know.

Anyway, I looked long and intently at it, and it did not move in all that while. It looks very satanic, that thing up there, and at first I almost imagined the Coventry City Council had taken to worshipping the Evil One, but a policeman (policemen are the repositories of much knowledge) told me it was intended for St. Michael, whereupon I was immensely relieved.

But it is not a good St. Michael that can appear to the wayfarer in so diabolic a disguise as that.

What a St. Michael can be is shown in the sketch I made at Mont St. Michel, in Normandy, where the great castle and abbey have been in process of restoration by the French Government for many years past, and where, a few years ago, the lofty *flèche* was crested with a glorious figure of this saint.

I have no notes of its size, but it is on the grand scale, and it is most refulgently gilded. Only in artistic

The peculiar weathervane on the Market Hall, Bampton, Oxon.

France could so daring and successful a figure be possible.

If you want to know where the largest weathervane exists, I think I can tell you. It is "La Giralda," on the steeple of the Cathedral at Seville.

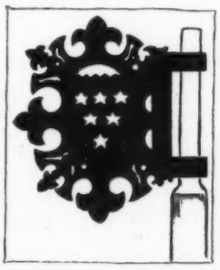
"Giralda" is, I take it, a thing that gyrates, and it just means, therefore, in Spanish, I suppose, a weathervane. The French for weathervane is "girouette."

The gilded bronze figure at Seville typifies Faith, and faith is a very suitable thing in such a situation; but it ought not, I think, to be a weathervane, because, if I view it aright, Faith should be steadfast against all the winds that blow.

It is a very old vane, this Seville example, dating back to 1568. It is fourteen feet in height, and it weighs one ton and a quarter.

We have nothing so monumental as that in England, but we have at Etchingham Church, in Sussex, an older. This is the copper, banner-shaped vane bearing the armorial cognizance of Sir William de Etchingham, who died in 1389. It is a simple shield of arms—"fretty," as heralds term it—and it looks well in a pierced sheet of metal.

There is, or was, for I will not declare that it is



Ancient weathervane at Oxburgh Hall, Norfolk.

there still, another ancient weathervane of the heraldic sort at Oxburgh Hall, Norfolk, the home of the Bedingfields for many centuries past.

The essential part of this armorial vane is formed by the six five-pointed stars. All the rest of this very elaborately pierced work is a misbegotten idea of decorative effect, which in reality obscures the heraldry.

It will be observed that I speak of "weathervanes"

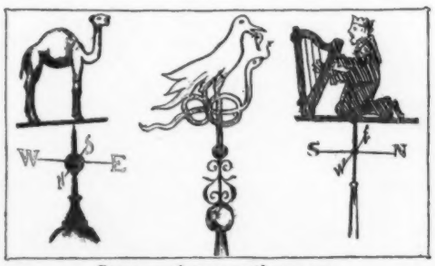
"La Giralda," on the steeple of the Cathedral at Seville in Spain, the largest weathervane in existence.

chiefly. It is done of set purpose, for, although weathercocks and vanes serve the same object, they are, correctly speaking, different classes of things.

A weathercock does not offer much chance for originality, and it is most often seen on church steeples. It is rightly placed there, for the cock is the symbol of vigilance, and that is why the Church has adopted it.

Occasionally, as we have already seen, there are vanes on church towers and spires, but they have no religious meaning as a rule.

One that I know of is, like the architecture of the building itself, frankly pagan. That is the gilded vane on the spire of All Saints', in High Street, Oxford. It is very curious, and represents a flame blown in the wind.



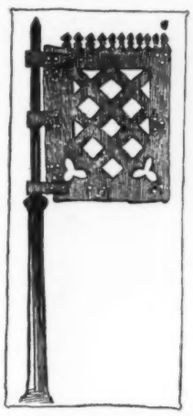
Some curious weathervanes.

Left: The camel vane on the Town Hall at Camelford, in Cornwall. Center: The dove and serpent's vane, Hethersett Church, Norfolk. Right: King David vane, on Copdock Church, near Ipswich.

There is, on the contrary, a curious vane of some religious feeling on the tower of Copdock Church, near Ipswich. It represents King David kneeling and playing the harp.

The name of Copdock means "the pollard oak," as written, "aet thar coppedan ak," i. e., "At the copped oak."

At Bampton, in Oxfordshire, anciently known as appears from the early Saxon charters, in which it is "Bampton-in-the-Bush" because of the almost complete lack of roads all around it, there is an extraordinary vane on the Market Hall. Who or what it is intended to represent has not been revealed to me, even after the most diligent of inquiries, but I throw out the sugges-



Banner-shaped weathervane at Etchingham Church in Sussex.

tion that it is intended for Joseph fleeing from the scandalous attentions of Potiphar's wife.

If this be so, then here is Joseph, hasting away with his clothes under his arm. He seems to be in a hurry. But perhaps it is only a reminiscence of Bampton's oldest inhabitant aroused at midnight during an alarm of fire.

As that everyday philosopher, the Cockney person, would remark, "You never know your luck." This was exactly exemplified some while ago on the Promenade Pier at Dover, when an angler had an extraordinary catch.

Having obtained what he imagined to be a bite, he encountered a resistance unusual, if not unprecedented, in all his experience. Summoning aid to land this exceptional monster of the vast deep, there was at last hauled up a small whiting—and the iron weathervane of the lighthouse!

The vane had been lost several years before, when a large sailing ship had come into collision with the lighthouse and knocked it over. It is perhaps hardly

The Lucy vane at Charlecote, Warwickshire.

necessary to add that my brother journalist who recorded this true incident prefaced it by the jocular caption, "A Vane Tale," thus impugning his own veracity. But, on second thoughts, I should really suppose it to have been a sub-editorial addition. Sub-editors are like that, you know.

One of the prettiest vanes I have ever seen is that of Hethersett Church in Norfolk, near Wymondham. It is in the form of a dove and two serpents, and displays that device because the living is in the gift of Caius College, Cambridge, this having been the crest of Dr. John Caius, the re-founder of that college, whose official title is "Gouville and Caius."

"Caius," as almost everyone, of course, knows, is by no means pronounced as spelled, but rhymes with "keys."

The Town Hall of Camelford, away down in Cornwall—and I think it is the Market Hall as well, for in those little West of England towns there is not much municipal business doing in a general way—has for weathervane the effigy of a camel, that being the old badge of the town.

It originated in the romantic but ill-informed days of Queen Elizabeth, when folk thought the place name of Camelford was evidence of some affinity with camels. This, of course, is not the case, the name meaning "the ford on the winding, or crooked river." The River Camel does in fact go in twists and loops.

"Cam" or—in the wondrous permutations and alternative spellings in the Welsh language, which, of course, long survived as a language in the West of England, as it does in the principality—"Gam," means crooked. Thus comes the expression you hear in some parts of rural England, of so-and-so having a "gammy" —that is to say, crooked—leg.

For the reason that he was physically a crooked person, the original and historical David Gam, who appears in Shakespeare's "King Henry the Fifth," got his name.

Which brings me to Charlecote, that historic mansion of the Lucy family in the Shakespeare country. The heraldic banneret vanes still twirl above those storied turrets, displaying the three luces, or pike, which form a pun on the family name.

In conjunction with the three cross-crosslets which the Lucys have borne for hundreds of years, those fish are disposed in a curiously symbolical way, in conjoined threes, to typify the Three in One, the Trinity.

For my own part, being an observant person, I get a good deal of quiet amusement from many church towers that have four pinnacles, and on each pinnacle a vane, because it is really extraordinary how rarely you will find all four of them in unison. They are all too often at variance—like other "experts."—*Wayfarer, in The Autocar.*

On Volume in Biology*

By Lawrence J. Henderson

In one respect this subject is time-honored. Herbert Spencer and many others since his day have recognized the biological importance of the principle of similitude. Bulk increases as the cube of length; surface as the square. Hence the limitation of the size of cells, the minute canalization of the body, and the prodigious jumps of the flea, as well as the variation in metabolism with the size of the organism. Yet even this subject is by no means exhausted. For example (a fact which appears to be of some importance in describing the internal regulation of temperature) the difference in temperature between center and surface of a sphere which is producing heat uniformly throughout its whole mass, when equilibrium has been established with a surrounding liquid medium of constant temperature, is always practically proportional to the square of the radius.[1]

But apart from this great principle and certain superficial discussions of the nature of oedema and similar phenomena, the regulation of volume has remained without any physico-chemical analysis. Yet, from the standpoint of physical science, this is perhaps the most universal and fundamental of all organic regulations. I believe that this strange neglect may be traced to three facts. In the first place, the chemist is accustomed to vary the volume of his systems to suit his convenience. This is a justifiable practice, because, if the phases are so large that capillary phenomena may be disregarded, and so small that gravity need not be taken into account, the division of a phase into two parts does not change its energy. Thus, volume hardly enters our calculations except as an indirect expression for that which is regarded as the true variable, viz., concentration. This, however, is to disregard the real question as it presents itself in biology. Secondly, *when equilibrium has been established* in a heterogeneous system, as Willard Gibbs rigorously proved, the volume of the phases—capillary and gravitational phenomena being absent—is not relevant to the state of the system. But it may be at once observed, first, that until equilibrium has been attained the volume is of great moment, and, secondly, that equilibrium is never attained within the organism. Finally, the ordinary conception of the process of diffusion is based upon a mathematical discussion, which, though leading to a consistent description of the phenomena, is nevertheless a false representation of the actual occurrences. And nearly all physiological changes of volume depend upon diffusion.

Contrary to a general though vague belief, the regulation of volume is theoretically independent of osmotic pressure regulation. For example, if a kidney produces a liter of urine of the same freezing point as blood, it must have diminished the volume of the body and left the osmotic pressure sensibly unchanged.

For the purpose of discussion, the activity of the kidney may be reduced to the following fiction: First, there must be an excretion of all the dissolved constituents of blood plasma, including water itself, in such amounts as to bring the composition of the blood in all respects to a hypothetical normal composition; secondly, a certain portion of this normal plasma, minus the colloids, must be removed in order to regulate the volume.

Statistically the volume of the urine must vary with the magnitude of the volume regulation, although, in particular cases, it need bear no relation to this quantity. Now sodium chloride is the principal constituent of blood plasma. Hence, statistically the ratio $\triangle$: NaCl (i. e., the ratio of freezing point depression to sodium chloride concenration is urine) will be small when the volume is large, and large when the volume is small. Thus, we arrive at a theoretical deduction *a priori* of Korányi's coefficient.[2] This coefficient tells us, therefore, nothing about the mode of action of the kidney mechanism. It has no bearing on the question of the functions of glomeruli and tubules. For the ratio is seen to be, as existing evidence proves, necessarily liable to indefinite fluctuations in particular cases. There is involved merely a statistical truth, expressing the conditions under which any kidney must operate in case sodium chloride is the chief constituent of the blood.

The practical importance of this theoretical discrimination of volume regulation from the excretion of the several urinary constituents appears to be established by the fact that in pathological conditions the daily volume of urine may be constant during variations in amounts of water or salt ingested, even when such experiments lead to fluctuations in the physico-chemical properties of the urine.[3] For this shows that the regulation of volume may be deranged more or less independently of the proper excretory functions.

If the final stage of volume regulation has been neglected, the intermediate stages have been generally misconceived. Neither the swelling of colloids nor the pressure which results from osmosis can furnish the basis for an analysis of such phenomena. In their stead we must turn to the kinetic theory and to Willard Gibbs' thermodynamics. But it should be first remarked that osmotic "pressure" and colloidal swelling "pressure" hardly act as important sources of mechanical tension, in the living organism. Even oedema involves very small magnitudes of such pressures. Secondly, changes in volume merely consist in the passage of material from one phase to another (exception in so far as physical and chemical changes within a phase may produce very slight fluctuations in volume). Finally, apart from the operation of special secretory mechanisms which we do not understand, such processes consist in the diffusion through phases and across interfaces from points of higher to points of lower potential. In the internal phenomena and less than in the exchanges with the environment, and in the internal phenomena of a single phase no less than in the heterogeneous process, water is quite as much in question as the dissolved substances.

This fact has been generally overlooked, by the physicists even more than by the physiologists. We may consider a simple diffusion experiment in which a layer of water is placed above a layer of sugar solution. It is true that the sugar must diffuse up into the water, but it is also true that the water must diffuse down into the solution. Yet the phenomena of diffusion have always been discussed with the help of the mathematical theory of heat conduction as exactly defined by Fourier. Thus Fick's theory of diffusion overlooks the *rôle* of the solvent. This has been possible because the process takes place *as if* the solvent were inert and the dissolved substance possessed a higher diffusibility. But the diffusion of the solvent is probably greater than that of the solute, in that water is, with a few exceptions, the most diffusible of substances. In their neglect of the relativity of motion, contemporary accounts of diffusion involve an old fallacy that occurs even in the astronomy of Ptolemy.

It may perhaps be objected that throughout the organism water exists at a uniform potential. This, however, is both untrue and beside the point. For, if two phases are free to exchange material, an exchange involving all their components will take place unless, at the outset, all their components possess the same potential in both phases. Thus, as Höber[4] has shown, isotonic solutions of sodium chloride and magnesium sulphate change in volume when brought into contact. For the chloride diffuses faster than the sulphate. Thus the sulphate solution becomes more concentrated and, as a result, water diffuses into it from the chloride solution. In like manner differences of pressure and of temperature influence the potential of water and of all dissolved substances. Finally, the processes of metabolism are continually altering the concentrations of solutions, and therefore the potential of water.

When these facts are taken into account, it becomes clear that the chief physical factor in the internal regulation of volume is water, through its distribution between the infinite assemblage of phases which make up the organism. The general concepts of the phase rule reveal the several elements of this process—except those which depend upon so-called selective activities—but the physical theory of diffusion, and therefore the whole kinetic description, has been developed from a false representation of the process, which neglects the movements of water itself. Only when this is immediately evident, as in osmotic phenomena, is it at all taken into account. But even here the current explanations are often incomplete. And the general theory of the diffusion of water is almost useless for the purposes of physiology. Yet there seems to be no reason to doubt that, in the organism, this is the most important process of diffusion.

Rotary Engines

Thousands of misguided inventors have spent their time and money developing inventions of rotary steam engines, but so far as we know there is not a successful rotary steam engine on the market to-day. In view of all the thought and energy that has been expended on the problem, this seems strange, until one has given the matter careful analysis. The rotary engine apparently has one advantage over the reciprocating engine—the absence of reciprocating parts, which in any machinery are disturbing elements. They eat up energy when run at high speed and cause serious vibration and rapid deterioration. It seems, then, that a prime mover in which these disturbing elements are absent would be superior to one having reciprocating and oscillating parts. While this is true, the fact is that the rotary engine has a number of disadvantages far more serious than this.

It is a matter of extreme difficulty to make a steam-tight joint between moving parts of any except circular shape. A bored cylinder fitted with a piston containing expanding rings may be made practically steam-tight, but it may be safely asserted that in practically no design of rotary steam engine has it been found possible to fit the moving parts so closely that they would be steam-tight without causing tremendous frictional resistance. The advantage of the rotary steam engine of the ideal type is absence of reciprocating parts. Against that single advantage may be placed the following disadvantages, which we have arranged in the logical order leading up to the greatest one—wastefulness:

1.—Difficulty of making moving parts steam-tight.
2.—Excessive internal friction and resistance.
3.—Steam leakage.
4.—Excessive steam consumption.

Excessive steam consumption is due to the inherent defects of design. It is quite feasible to provide for cut-off in the stroke of a rotary piston, the same as in a reciprocating piston, and in this case the same economy would result were it not for leakage and friction.

In view of the inherent defects of the rotary steam engine, it seems little less than madness to attempt to develop a rotary gas engine. In the rotary gas engine the difficulties of securing gas tightness are greatly increased. The inventor has to cope also with high temperature and great differences in temperature at the beginning and end of the working stroke.—*From Machinery.*

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*Proceedings of the National Academy of Sciences.

[1] I am indebted to Prof. W. E. Byerly for kindly calculating the value of this difference which is $p/k \cdot r^2$ 6, where p is rate of heat production, k conductivity, and r the radius.

[2] A. v. Korányi, *Zs. Klin. Medizin*, 33, 1892, and Korányi und Richter, *Physikalische Chemie und Medizin*, Leipzig, 1908, 2, pp. 133-224.

[3] *Ibid.*, pp. 165, 166.

[4] *Pflüger's Archiv*, 74, 225 (1899).

Bacteriological Retting for Ramie, Flax, Etc.*

Use of Cultures in Retting Bast Fibers Perfected

By H. A. Carter

THE prospects of ramie and China grass fiber being used in the near future upon a greatly increased scale, are said to be improved by the recent invention by James Rossi, professor of bacteriology at the Royal College of Agriculture, Portici, Naples, Italy, of a bacteriological and wholly non-chemical process for the quick, economical and effective retting of these fibers. The process is applicable with the same success to the retting of flax and hemp. Another great advantage which attaches to it is the fact that it is simple to operate, and the plant and apparatus needed is not costly. A plant to ret five tons of any of these fibers weekly can be laid down at a cost of about $2,000.

The genuine merits of the process were recognized some time ago, and it has been employed for the past two years for the retting of all the above fibers on a large scale by Le Société Francaise du Rouissage Industriel, of Bonnetable, Sarthe, France. Samples of flax retted by it have lately been forwarded to, and carefully examined by a firm of Yorkshire flax manufacturers, who consider the flax produced to be of excellent quality, quite equal to the twice-retted flax of the River Lys in Belgium, and state that the loss in weight in the retting, waste made, etc., by the process is no more than that made by the methods commonly in use, such as water steeping, etc. The cost of operating the process is about $8 per ton of China grass, ramie, flax or hemp retted.

With respect to China grass and ramie, which in their crude state are fibers admirably suited for textile manufacturing purposes, it is well known that, so far, a great objection raised by manufacturers to using them largely in mill operations, is the fact that they are at present almost everywhere retted, or degummed, by chemical process, and many manufacturers believe that in numerous instances this chemical treatment damages the good natural qualities of the fibers for textile manufacturing, and weakens the strength which they naturally possess. As a matter of fact, it is not impossible to ret ramie and China grass by chemical agency without harming the natural qualities and strength of the fibers. If this were not so we should not have had large mills in Europe successfully and profitably manufacturing ramie for a dozen years past and producing very beautiful and silky textiles from it.

There are about a dozen chemical processes in existence for retting China grass and ramie which are quite a success, and not costly to operate, still, the fact remains that these fibers are undoubtedly very frequently damaged by faulty chemical degumming, when their use in textile manufacturing operations brings much disappointment. These processes, further, do not accomplish the retting nearly so cheaply as the new "Rossi" non-chemical process, though they produce a rather finer and more silky fiber which is better suited for the manufacture of fine and superfine ramie and China grass textiles for which large markets will open, in the opinion of the writer, once the raw material becomes more plentiful and cheaper.

For all rather fine, medium and coarse textiles produced from these fibers of good linen quality, the Rossi method is claimed to be the most suitable, and the largest market is for these classes of materials. There is no doubt a future of great usefulness for the new bacteriological retting process, and manufacturers, moreover, can always fearlessly use fibers retted by it for the reason that as no chemical agents whatsoever are utilized in carrying out the Rossi process, nothing is done to the fibers which can possibly cause even the slightest damage on the good lasting strength which China grass and ramie fiber possesses naturally in their crude state. The retting of these fibers is accomplished by it in three days, while it will successfully ret flax in 34 hours, compared with the 10 to 14 days now needed for the retting of flax in hot water in tanks.

Ramie produced by the Rossi process is the exclusive product of microbiological maceration, rinsing in pure water, and carding, and does not suffer any chemical treatment of degumming and bleaching. The vegetal retting process forming the subject matter of the Rossi patents is, in addition, totally different from the so-called retting cultures at times sold in the United States, inasmuch as it is based on the discovery made by Dr. Rossi that a gas current is able to regulate and increase the retting effect of pectic aerobic microbes, hitherto held to be ineffective for agricultural and industrial purposes, so as to make it industrially utilizable. Prof. Rossi is said to be the only person who cultivates the really efficacious microbes which under the action of air will macerate China grass and ramie within three days. The use of these he will only grant to those who employ his patent process.

The process comprises the following steps, the China grass, ramie or other fiber to be retted may, if necessary, be previously cleansed by washing and then put into suitable vessels. It may be pasteurized or sterilized, or not, after which a quantity of water is poured in sufficient to cover the material. The whole is then left to itself, or, according to the kind of material to be retted, or the degree of retting or degumming desired, is pasteurized, boiled or sterilized. This pasteurization and sterilization may be easily carried out by heat, in which case the vessel is provided with a suitable heating device. Antiseptics may be used as well, but should be eliminated after being used.

The vessel is provided with a suitable device permitting of having an air, or other suitable gas current pass continuously, or nearly continuously, for the whole time of retting throughout the entire height of the liquid contained therein. Before the gas reaches the retting vessel it is caused to pass through a suitable sterilizer, e. g., a tube filled with sterilized cotton wool, or like material. The vessel is tightly closed by a cover. Through an inlet, equally capable of being tightly closed, a suitable quantity of pure bacilliculture (Rein Kultur), of a pectic aerobic microbe is poured into the vessel, such as Bacillus Comesii Rossi, B Kramerii Rossi et Carbone, etc.

If the vessel and its contents were heated they must be previously cooled down and heated with the utmost antiseptic precautions. Thereupon the inlet is closed and a gas current, as stated above, is passed through the contents of the vessel.

It is well to keep the retting liquid at the beginning, and during the whole time, at a temperature as near as possible to that most favorable for the growth and reproduction of the retting microbe used, and to keep the space in which the retting is effected, during the whole time of retting, at an analogous temperature. It is also well to provide the vessel with a lateral tightly closing tube, capable of being closed and opened without interfering with the asepsis of the vessel, and communicating with its interior, from which samples may be taken from time to time in order to ascertain the degree of retting of the contents of the vessel.

Apparatus in which the process may be carried out has been devised and patented and its design resembles that of the commonly used bleaching kier. A partition keeps the material immersed during the retting. The microbes are admitted to the vessel through a pipe. There is a sterilizer, reservoir or air pump, and a pipe enters the apparatus at the top, preferably provided with a plug of cotton wool to prevent microbes from entering by it, so that a gas current may pass through the ramie or other material. By the sample-taking the proper time may always be ascertained when the operation is to be interrupted. As soon as this is the case the vessel is opened and the retted material is removed.

The above described process is one which may be followed if it is desired to be absolutely sure of not meeting with inconvenience. When the ramie is being treated it is well to complete the separation of the impurities and of the pectic substances, which latter have only been made soluble by the retting process, by washing with water without the use of chemical reagents. The Rossi process produces a fine flax-like fiber from ramie and China grass.

The loss in the retting, washing included, is not more than 15 per cent and the process does not throw off any bad odor in working. For every ton of fiber retted Prof. Rossi states we can count on 850 pounds of ramie fiber. The yield got after combing, he adds, is of course variable according to the machine used, but he has got 44 per cent of combed fiber, using quite an unfit machine. English combs yield more. Thomas Barraclough, of Cheltenham Mount, Harrogate, Yorkshire, England, it may be observed, an expert in machinery for preparing and spinning ramie, says one ton of degummed or Rossi-retted ramie or China grass fiber, good quality, will give when combed about:

390 pounds long fiber, 7 to 10 inches.
390 pounds, medium fiber, 4 to 7 inches.
770 pounds short fiber, 1½ to 4 inches.
690 pounds noils less than 1¼ inches.

2,240 pounds.

The long, medium and short fibers produce an excellent yarn, if the degumming or retting has been perfect, and even the noils make a regular strong yarn.

It is well known that when it is endeavored to ret ramie and China grass in the ordinary manner that there is so much green and gummy matter in them that the fermentation proceeds too rapidly. The useful fibrous bast rots quicker than the cuticle, and it is in consequence of the presence, naturally, in the ramie of certain baneful microbes that this is the case. Now the pectic microbes, which are used in the Rossi process, being in the best conditions of existence, and being aided by the gas current, which is one of the prominent features in Prof. Rossi's invention, overcome the other microbes in the retting vessel when they are introduced into it from the atmosphere.

As to the strength of crude ramie fiber, Sir D. Prain, director of Kew Gardens, Richmond, England, where ramie is grown for experimental purposes, says that in all the years he lived in districts in India in which ramie is grown, he never heard crude ramie described as a brittle fiber, or a fiber defective in good strength, nor does he think it is, and it is worth noting that the famous Prof. Wiesner, of Vienna, who has a world-wide reputation as a botanist and fiber expert, declares in one of his books that in respect to elasticity, flexibility, power to successfully withstand great and sudden strain, compression, tensile and torsional strength, ramie is quite equal to the best flax and at times has been found to possess these qualities to a greater degree than flax, though it is not as elastic or strong as cotton or silk. The famous British botanist, Roxburgh, and later Dr. Royle, spoke regarding ramie in very much the same terms.

Retted by an absolutely non-chemical process like that invented by Prof. Rossi these natural good qualities cannot possibly by impaired. China grass is, however, the particular kind of raw ramie which the process rets most easily and successfully. China grass is the name given to ramie cleaned by hand by the Chinese in China, but the process will also ret fresh green ramie ribbons having the whole of the outer skin, or cuticle, attached. It is not successful with ramie ribbons which have been dried, says Dr. Rossi.

For those who are interested in the cultivation of ramie it may be observed that a very good article upon this subject containing many new and valuable hints on how to grow a perfect fiber, appeared in the June issue of the monthly journal *Tropical Life*. Herbert R. Carter, Belfast, Ireland, a well known flax machinery expert, lately gave it as his opinion that the existing machinery in flax mills can easily and cheaply be adapted to spin an excellent yarn from ramie, or China grass fiber, from which some beautiful and fine textiles are daily manufactured in Europe.

The weaving of ramie and China grass fiber yarn mixed with linen yarn should give a great impetus to the linen trade because these fibers possess hygienic properties of a high order. Ramie and China grass fiber rapidly absorb and fully and quickly throw off the moisture and perspiration of the body when worn as body linen or suitings. This protects wearers in tropical and hot climates from contracting chills by the sudden changes in the temperature. The above blending imparts a fine silky luster and increased strength into the resultant cloths. Blending also produces a cloth lighter in weight than a pure linen cloth.

For the manufacture of certain special kinds of materials such, for example, as fire hose, there is no fiber so suitable as ramie, for it is less susceptible to atmospheric conditions than any of the other fibers, and does not rot when immersed in water. This fits it well for the manufacture of sail cloth, sea linen, fishing lines and nets and army tent canvass. Ramie when it becomes cheap enough will be largely used for these latter manufactures, and it will then, especially when retted by the Rossi patent process, produce the most durable as well as the best health-giving khaki uniforms for soldiers.

*Textile World Journal.

Panorama of the Palatine, with the remains of the Imperial Palace.

New Excavations on the Palatine

Discoveries That Are Throwing Additional Light on the Ancient History of Rome

By Commendatore Prof. Giacomo Boni

THE excavations on the Palatine, which were commenced about three years ago under my direction, are progressing slowly but steadily, and new and important discoveries are constantly being brought to the light of day. Some idea of the extent of the excavations and restorations which I have undertaken on the Palatine Hill may be obtained from the fact that, notwithstanding the staff of assistants and skilled workmen engaged, and the generous support of the Italian Government, which appropriates about 150,000 francs annually for the purpose, the work is likely to go on indefinitely, without ever being entirely completed.

The most important of the Roman hills is the Palatine: it dominates the valley of the Forum, and contains the ruins of the palace built by the architect Rabirius, about A. D. 91, for the last Emperor of the Flavian dynasty. It has been proved that the valley of the Capitol and the Quirinal was not excavated by man, but had been furrowed by the prehistoric Tiber. Therefore, in beginning the exploration of the imperial palace on the Palatine, I thought it was necessary to ascertain at the outset whether it occupied the site of a valley, the so-called *Intermontium*, or whether, as I supposed, it occupied the summit of the original hill, a far more conspicuous and noble site for such an important residence. The preliminary researches proved the latter view to be correct. Only a few feet under the atrium, the central court of the palace, I reached the primitive archaeological layers, resting upon the top of the clay which covered the volcanic leucitic tufa nucleus of the Palatine, and of the other Roman hills.

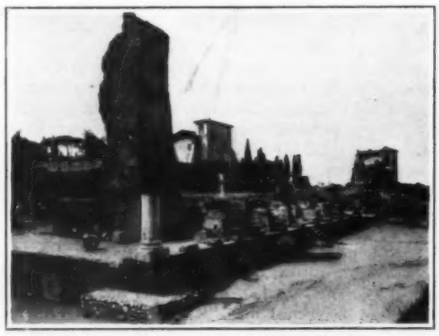
Having thus ascertained that the imperial palace occupied the top of a hill, not the bottom of a valley, I came to the conclusion that the earlier imperial palaces, and their first prototype, the house of Tiberius, must have occupied the same site.

The late republican houses, some of which have been described to us as being the richest and most important in Rome, must have enjoyed a view of the distant Alban hills, and of the valley of the Forum from the slopes of the hill itself. In later times these houses were leveled down to make place for the successive rebuildings of the imperial residence, as it grew larger and larger. In the days of Domitian the imperial palace seems to have been a colossal domicile, that is to say, the ordinary Roman house, multiplied by six; just as the statue raised by Domitian, in the center of the Forum, had the same colossal proportions.

I hoped that it would be possible, by discovering some of the houses of the republican period which were buried under the palace, that we should be in a position to study the biography and to analyze the evolution of the structure of the houses themselves, in order to find out their primitive form and shape, and eventually, perhaps, to reach those elementary prototypes of the Roman residences, the huts of the primitive Latin inhabitants of the hill sacred to Pales, the shepherd goddess. It is of great importance to determine the site, the shape, and grouping of such primitive Latin dwellings on the Palatine, because the shape of the huts themselves may give some clue to the origin of the progenitors of the Romans.

The Romulian people, who founded Rome, were most probably shepherds, just issuing from nomadism, while the Sabines, who occupied the Capitoline Hill, originally the *Pagus Saturinus*, had already by this time attained to the agricultural stage of a people who had ceased to be nomadic. . . .

Geological formations are differentiated by their composition, texture, and by the relics of organisms found in them; and geological science has advanced so far that it is possible to say beforehand what fossil remains will be found in a given formation, if the stratigraphical position of that formation shall have been correctly determined. In the case of archaeological accumulations, some of which have remained unknown till now, it is



Remains of house of Domitian and the Basilica.

absolutely necessary, if we are to raise archaeology to the level of a science, to be very careful to study the materials and the structures in their definitely ascertained chronological order.

This method of analysis, by which I was enabled to attain scientific accuracy in the exploration of the Forum, I have applied to investigation of the Palatine: I began my exploration on this hill in the area of the private basilica on the right hand side of the entrance to the palace, adjacent to the vestibule or throne room of Domitian.

The large crevices, caused by earthquakes, which split the whole of the Palatine hill, had also extended through the wall, close by one of the arches in the wall of the basilica. I knew that these arches indicated that there was something hollow underneath. I searched there and found a staircase leading down to a piscina of the time of Nero, of which five large compartments still remain, carefully plastered with *opus signium*, which, however, is much decomposed by sodium chloride

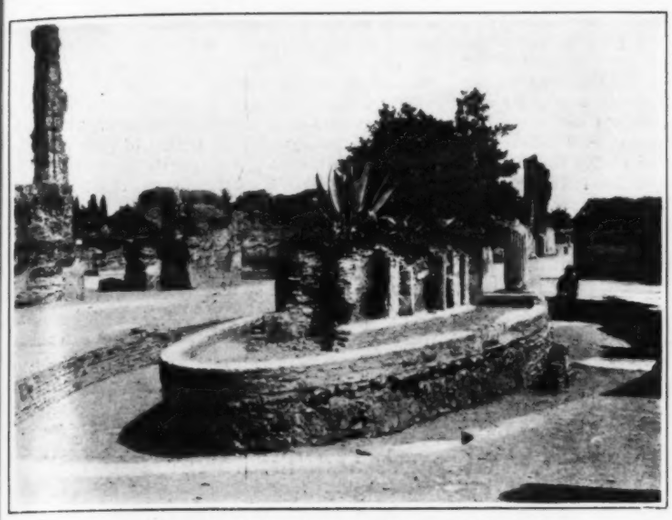
We are told by Suetonius that Nero caused sea-wate to be brought from the sea to the Palatine, and su phurous water from Tivoli. This latter was evident meant to be used for bathing, but the sea-water for th purpose of keeping fish. The chambers of the piscina communicating through arched doorways, remind on of what Varro says of the Roman fish-tanks or pi cinae; he compares them to the palette of a painte which is used to keep the colors separate. So in th piscinae the fish of different varieties were divided, th smaller from the larger, one kind from another, b means of nets.

Close to this piscina I discovered an older structure It is one of the houses of the last years of the Republi The house is a most important one, because the centra hall, cut through by the cylindrical substructures o the Neronian piscina, is decorated with fresco painting important from both the artistic and historical point o view, since they reveal the importation of symbol and of ornaments from Egypt and Asia Minor. Thes paintings are also technically important, as they ind cate new pigments, which the invasion of Egypt intro duced to the Romans and which they adopted in thei frescoes.

The early Greek paintings were based on four colors white, black, red and yellow. These colors could easil have been got by the early Roman from materials ob tainable from the mineral deposits in central Italy, o from burning pine resin. But the pictures in the hous which was cut through by the piscina, reveal to us t most magnificent and gorgeous polychrome entirel unknown to the primitive Romans, its effect being especially due to the lavish use of coeruleum, which i a light blue silicate of copper imported from Alexandri a color so much admired that, in the days of Vitruviu cheap imitations of it were the fashion. The mixtur of this blue with the best yellow ocher produced variou tones of green. The red panels are of the most brilliant vermilion, which was procured from Monte Amiat Some of the floral decorations are painted a brilliant purple color, obtained from the *murex*.

In the construction of this late republican hous again, a still more ancient house has been cut through of which the staircase, in *opus incertum*, is still pr served. Under this staircase runs one corridor of th *favisse*, a mysterious system of hiding places, store or treasure rooms, which runs under the whole exte of the Palatine.

The exploration of the republican houses, under th basilica of Domitian, has supplied the first importa data concerning the geological structure of the hi It has shown that the houses themselves were built o a level surface, which was obtained on the easter slope of the hill by removing a thick layer of clay fro the top of the horizontal surface of the underlyin tufa rock. In order to carry out these researches o



Remains of Nymphaeum, with an oval fountain.

The palace of Flavi, with piscina.

a larger scale, I began to explore the adjoining vestibule of the palace: a magnificent hall, 120 feet wide, where Heraclius was crowned as the last Emperor. Here, near the principal entrance, I was able to determine the chronological succession of the imperial palaces. I saw how the substructures in silex-concrete of the palace of Domitian had cut through the substructures in travertine-concrete of a previous palace, probably that of Nero, which, in turn, had cut through the old concrete substructures, containing late republican terra-cottas and broken tiles and belonging to a still older palace, probably that of Caligula.

All these foundations of the three imperial palaces, of which we now know the chronological order, met in a certain spot, and were cut through the threshold and vestibule of another house of the late republican period, originally belonging to a patrician family such as that of Catiline. The threshold and the pavement are in slabs of the most beautiful and precious African red breccia separated by slabs of green-veined cipoline marble from the island of Euboea. I discovered also that the atrium and the lateral rooms, or *cubicula*, were paved with marble slabs, which covered mosaic floors belonging to an earlier period. These mosaics are not composed of fragments of marble, but are of pebbles from the Umbrian confluents of the Tiber, red, yellow, green, black and white limestones, grouped so as to produce a polychromatic effect which is not only beautiful in itself, but historically interesting as being important evidence of that inspiration toward a kind of decoration, a taste which the Romans were able to gratify to the utmost later on when they came into contact with the eastern and African marbles.

It appears that the new owner of the house, toward the beginning of the Augustan era, covered the old mosaic pavements with slabs of marble, demolished the original first story, which had been destroyed, and threw down fragments of architectural remains, stuccoes and the like, which filled up the basement rooms of the original ground floor. These remains have been most valuable, for I have been able to study in them the whole architectural and pictorial decoration of the older house. The original ground floor itself is decorated with stuccoes and pictures of interest to geologists, as they represent panels inlaid with sections of silicious pebbles displaying the wavy concentric layers of chalcedony and agate, while the architectural framework in which they are set shows the first attempt at parallel perspective. Under this ground floor are layers containing the terra-cotta decorations of a still older republican house of the third century B. C., also a row of grottoes, cut in the tufa, filled up with the remains of what appears to have been a yet older house, if we may judge from its terra-cottas, which are of the archaic period, and from the relics of the life of the family, who seem to have occupied the site somewhere between the sixth and fifth centuries B. C. Among these interesting relics, we found indigenous pottery, some articles meant for cooking, some for the table, Campanian ware, black Etruscan *bucchero*, and the most exquisite early Attic, with inscriptions in archaic Latin, Etruscan and Greek. These remains reveal the presence of different races, and indicate intercourse and communication about the time of the Gallic invasion of 390 B. C.

These various remains, moreover, enable us to recognize the stage of development of the inhabitants of the Palatine in the early republican days; and they give us approximately the date at which the *favissae* below were filled up. But the date when these excavations were first made is still to be discovered.

The first row of *favissae* under the republican house has several rectangular and cylindrical shafts leading down to corridors and galleries. These shafts, in most cases placed only a few yards apart, seem to have served for ventilation purposes. The corridors and the galleries at the bottom of the shafts lead to chambers carefully plastered, which were used as granaries or safe-deposits, and were well protected against damp. A large cylindrical shaft has been sunk through the first tier of *favissae*, and at a depth of sixty feet it cuts through another very extensive and complicated network of corridors and galleries shaped like the Christian catacombs. Similar *favissae* were found under the central part of the atrium, and under the house of Tiberius Claudius, which represents the actual prototype of the imperial palace. The Palatine *favissae* were supposed to be quarries, but their complicated structure, and the way in which they were plastered, made us look at them more closely, and compare them with similar excavations, which are to be found all along the Latin coast, as far as Nettuno. Research will doubtless one day reveal *when* the Palatine *favissae* were first excavated, *who* excavated them, and *for what purpose*. We may, perhaps, look on these subterranean chambers and galleries as the predecessors of the Christian catacombs, and make certain comparisons in regard to them, since the people who issued from the catacombs seem to have had many points of similarity with the indigenous Mediterranean race who had at first been subjected by the Latin Romans, and waited patiently, as plebeians, to re-emerge when the patrician families were withdrawn from circulation by nature. These patricians left behind them, in the sunlight of the Palatine and of the other Roman hills, many noble buildings, together with the evidence of their civilizing power.

Among other things, "Mechanics" has to do with my present researches on the Palatine. Years ago, under the central part of the Roman Forum, I found a group of twelve elevators, worked by capstans, and used for the gladiatorial shows of Julius Caesar. I was convinced that more powerful and complicated mechanical appliances must have been employed on the Palatine, and that these must have been on a much larger scale, on account of the greater difference in level between the Circus Maximus, which we may look upon as the ground floor of the imperial residence, and the official parts of the palace, about 120 feet above. It is obvious that the still higher level of the terraces to which the water from the Neronian Aqueduct had to be specially pumped in order to supply the necessary amount for the fountains, bathrooms, and for the irrigation of the hanging gardens, would demand a large amount of mechanical energy for raising water and for working the lifts and elevators for the rapid transit of persons and goods. We have also to account for

Remains of the stadium.

Remains of the house of Caligula.

mechanical power of sufficient magnitude to work the hydraulic organs and also to move the circular dining-room of Nero, which revolved like an astronomical dome, with the sun.

The most notable of the restorations which I am carrying on at the present moment is the marble pavement in one of the halls of Nero's palace. This pavement, of which only a few portions were found intact, was composed of slabs of colored marble arranged in an exquisite all-over scroll design. Red porphyry from Egypt, green serpentine from Laconia, Phrygian marble from Asia Minor and yellow from Numidia are the materials employed, and the effect is singularly beautiful. The entire floor has now been re-covered with white marble slabs, carefully joined to the fragments, and the scroll pattern is continued throughout the hall by being carved into the white inset. It is now possible to study the floor pattern as a whole. Not the least of my labors has been my transformation of the long-neglected Palatine hill into a beautiful garden. Two years ago, with the exception of a few large trees, the entire summit and slopes of the hill were covered with nettles and weeds. At my own expense I have planted over 10,000 trees and shrubs; 2,000 bushes, including many ancient varieties; about four hundred varieties of indigenous plants, many of which were used in the sacred rites and were dear to the ancient Romans; rows of pine trees, cypresses, laurels, larches, which latter were so much appreciated by Julius Caesar; also oleanders, jasmine, myrtles; and classical fruit trees such as quinces, pomegranates, and wild cherries, together with masses of ivy, convolvulus and other climbing plants. My plan in the introduction of flora on the Palatine has been to confine myself to four groups, the first, indigenous plants, the second, Mediterranean flora, then classical flora, and last, Renaissance flora. The result is that the Palatine is now a mass of gorgeous color and with the background of stately trees and shrubs forms a highly poetic setting to this classic and historical spot.

EDITORIAL NOTE.—The Italian Government has not as yet permitted any photographs of these new excavations here described by Prof. Boni to be made, but the accompanying illustrations show six scenes in the neighborhood where the work described by the author is being prosecuted, including some of the trees he has so generously planted.

Trinitrotoluene Poisoning*

Nature of the Material, Toxic Symptoms, Preventive Measures and Treatment

BEFORE August, 1914, there had been little practical experience of the toxic action of trinitrotoluene (T.N.T.). No ill effects had been observed from the small quantities used, and it was generally believed to be much less toxic than dinitrobenzene, which had been manufactured in this country on a small scale for many years and been used as an ingredient of explosive powders in a proportion rarely exceeding 15 per cent. During the past year, however, T.N.T. has shown itself to be dangerous to the health of at least a minority of workers coming into contact with it, and has produced fatal toxic jaundice in fifty cases out of many thousands of workers engaged.

As soon as the danger from T.N.T. became obvious, administrative measures for their control, including medical supervision in all the factories, were taken and scientific investigations into the modes of action of T.N.T. were organized. Whatever light is being thrown upon T.N.T. poisoning by such investigation is communicated to the responsible medical officers in the factories concerned for their guidance. Many cases of illness, however, attributed rightly or wrongly to T.N.T. poisoning, have, or may, come to the notice of medical men outside the factories, and it appears desirable accordingly to make generally known to them the present state of knowledge in this matter, as on them now devolves the duty of notifying toxic jaundice contracted in a factory or workshop to the Chief Inspector of Factories at the Home Office, London. Apart from such statutory notification, communications from medical men based on observations of any serious effects attributed to T.N.T. would be valued, and might be addressed to the same quarter. It is hoped to make in the early future further communications of results obtained by investigation.

Trinitrotoluene, also known as T.N.T. and trotyl, is a high explosive obtained by nitrating toluene—a product of coal tar distillation. Toluene is a benzene compound in which one hydrogen atom of benzene (C_6H_6) has been replaced by the radicle CH_3. In the process of nitration three other hydrogen atoms are replaced by the nitro radicle (NO_2), and the formula for T.N.T. may be written, $C_6H_2(NO_2)_3CH_3$. This body is solid at ordinary temperatures, in which state it can be reduced to a fine powder; it melts at about 80 deg. Cent.

When the skin or hair is exposed to T.N.T. by contact, a characteristic yellow or tawny orange stain is produced, which lasts in the integument for some weeks. Derivatives of T.N.T. produced by the action of alkalies have characteristic colors; if a dilute solution of T.N.T. is treated with alcoholic potash, a deep pink color changing to purple and then turning brown results. Skin which has absorbed T.N.T. has a bitter taste to the tongue, which is removable by solvents of T.N.T. but not by water, as in ordinary washing.

T.N.T. is soluble in oils and greases as well as in acetone, ether, benzene (benzol), xylene (xylol), and other compounds, and the importance of this will be referred to later. Alkaline alcohol changes the yellow stain in the skin to pink or purple, and the T.N.T. thus chemically changed is soluble in and can be washed out by water.

T.N.T. is used alone as a fine powder, or in a flaked condition, or in the molten state from which T.N.T. in vapor escapes and is deposited in the form of a fine crystalline sublimate upon any surface of lower temperature than about 70 deg. Cent. When mixed with 40 per cent to 60 per cent of ammonium nitrate it is known as amatol, and with 20 per cent of ammonium nitrate as ammonal. T.N.T., as used, is often impure and contains traces of dinitrobenzene and other similar bodies, but investigation has produced no evidence of its poisonous properties residing in impurities. Pure and crude T.N.T. are equally toxic, and in no cases have the separated impurities been found more potent than pure T.N.T. The separate T.N.T. isomers have also been carefully tested, and their toxicity appears to lie either at or slightly below the toxicity of T.N.T. Of the cases showing jaundice about 27 per cent have arisen from pure T.N.T., 67 per cent from amatol, and 6 per cent from ammonal. Possibly the hydroscopic nature of ammonium nitrate may assist absorption through the skin.

DINITROBENZENE POISONING.

A natural guide to the new experience of T.N.T. toxicity is to be found in the older knowledge of that due to dinitrobenzene (D.N.B.). It has long been known that D.N.B. may be readily absorbed by the skin, and it may be supposed that this absorption is affected or aided by the solubility of D.N.B. in the cholesterin fats of the skin or of greases used either in factory processes or as ointments. It may, perhaps, pass through the skin by the mechanical inunction of minute particles.

The most obvious results of D.N.B. poisoning by skin absorption are changes in the red blood corpuscles. As in nitrite poisoning, there is a conversion of oxyhæmoglobin to the more highly oxidized form methæmoglobin, and this change, if large in amount, produces breathlessness and cyanosis (both removable by breathing pure oxygen), which last until the body has been able to reduce the methæmoglobin to the natural form. Beyond this simple chemical result there may be, when the poisoning is more severe, hæmolysis, with degeneration of the corpuscles and escape of methæmoglobin into the plasma. In severe cases evidence will be found not only of destruction of the red corpuscles, but also of activity in the blood-forming organs; nucleated red corpuscles may be found in severe cases, with evidence of imperfectly developed corpuscles, as shown by the occurrence of basophile granulations, polychromasia, and variations in shape and size. Lymphocytosis may also occur.

If the dosage of absorbed D.N.B. is not too great, blood formation seems able to keep pace with blood destruction; cessation from work for a short time enables the blood to recover rapidly from the effects of poisoning.

In D.N.B. poisoning these effects upon the blood are by far the most prominent feature. In very rare cases toxic jaundice may occur. Thus, in 1906 a dinitrobenzene worker after three months' employment died in the Huddersfield Infirmary, having been admitted for symptoms of cyanosis, vomiting, jaundice, and dyspnœa. Post mortem the liver was stated to have resembled that of acute yellow atrophy.

These facts suggest that (*a*) while D.N.B. upon absorption produces in all persons alike its chemical effects in the blood, varying in degree according to dosage (this being dependent again upon conditions of work, precautions taken, and perhaps upon varying greasiness or permeability of skin), and according to individual powers or opportunities for blood recovery; (*b*) it produces as an additional phenomenon liver degeneration only in a small minority of persons in whom the body cells are specially susceptible to the poison.

CHLOROFORM AND DOPE POISONING.

Upon this view of D.N.B. poisoning, an analogy to it may be found in chloroform poisoning. In the vast majority of patients chloroform only shows its anæsthetic action. In a very small minority, however, it may also give rise to degeneration of the body cells, especially of the kidney or of the liver, and in the latter case it may kill by liver degeneration and atrophy, with accompanying "toxic jaundice."

A further analogy may be drawn from facts recently made prominent in connection with the toxic jaundice, which became serious in this country for the first time toward the end of 1914 among persons employed in "doping" aeroplane wings, as the result of the presence in the dope of tetrachlorethane ($C_2H_2Cl_4$), which, inhaled as a vapor, acts upon nervous centers, and is also a powerful liver poison. The toxic jaundice so caused has now happily ceased since tetrachlorethane has no longer been an ingredient of any aeroplane dope. During the time of its use at least seventy cases of jaundice with twelve deaths are known to have occurred. In the fatal cases the liver and kidneys were always the organs principally affected, and with changes indistinguishable from those to be described as induced by T.N.T. Alteration in the blood was absent, thus distinguishing the cases from toxic jaundice caused by nitro-derivatives of benzene and toluene. Here, then, we have a body, closely allied chemically to chloroform, which, while the anæsthetic properties as used industrially are not so prominent, finds a much larger number of persons susceptible to its toxic action on the liver.

TRINITROTOLUENE POISONING.

In view of the old experience of D.N.B. poisoning, it would appear *a priori* likely that T.N.T. can be absorbed in a dangerous degree by the skin, and recent experiments establishing this absorption will be mentioned below. Fine dust and fumes will reach, besides the exposed skin surfaces, the mucous membranes of nose and mouth—perhaps even the lungs themselves—and must inevitably be swallowed either in the saliva or with the mucous secretions from the nose and windpipe.

T.N.T. may be recovered unchanged from the fæces, and is probably there present in most of the workers. In the urine it does not exist free except by contamination during collection, but in the great majority of all workers it is present in greater or less amount in the urine, though in a combined state. In properly collected urine, not directly contaminated with T.N.T. dust, T.N.T. solvents fail to extract any of the substance. Its presence may be shown, however, by liberating it by acid from a compound in which it is fixed, when it may be revealed by its ordinary reactions. Further investigation is now in progress, but it would appear probable that free T.N.T. in the intestine is combined in the presence of reducing substances, just as other aromatic bodies in ordinary digestion of proteins are converted to ethereal sulphates, and so eliminated harmlessly by the kidney.

It appears at present best to group the symptoms of the poisoning under the following heads:

1. *Dermatitis.*

This appears to be due to a direct irritant action upon the skin. Some persons are more susceptible to it than others; the effects, like those of other irritants, are increased by flushing and perspiration, and by mechanical friction. Further details will be given below.

Some observers have thought that persons specially susceptible to dermatitis are in some rough proportion less susceptible to T.N.T. poisoning in the other ways to be mentioned. If further observations show this to be true, it may be a sign that some skins hold the

*Officially communicated by the Ministry of Munitions and published in *The Lancet*.

T.N.T. in combination and suffer local irritation, while other skins allow a readier passage of it to the blood.

2. *Digestive Troubles.*

Gastritis, with abdominal pain, vomiting, constipation (a very constant symptom) with flatulence and distension, may all be early symptoms, and may appear in the absence of actual liver degeneration. It would seem probable that T.N.T. may act as an irritant in the stomach or intestines, as it may in the skin, independently of internal toxic effects.

3. *Blood Changes.*

These appear to be the same in kind as, though less in degree than, those mentioned already for D.N.B. The presence of methæmoglobin may be demonstrated commonly in the blood of workers, though cyanosis and breathlessness are much less evident than in the case of D.N.B. poisoning. Further investigations upon the precise changes in blood are in progress. There seems little reason to doubt that those already recognized are due to a direct action of T.N.T. introduced to the blood as such by absorption from the skin or from mucous surfaces.

4. *Liver Degeneration, "Toxic Jaundice."*

While the blood changes due to T.N.T. absorption are less noticeable than with D.N.B., T.N.T. appears to produce cell degeneration more readily, with the resulting toxic jaundice when the liver is involved. Even with T.N.T., however, only a small minority of persons under present conditions of work have shown signs of toxic jaundice, and the fatal cases have been few in relation to the great numbers of workers engaged.

Upon the comparison already made between the toxic effects of D.N.B. with those of T.N.T. it may be suggested that the very prominence of blood changes due to the former diminishes, by the attention it arouses, the chance of grave poisoning of the liver, and that in the case of T.N.T. the comparatively small note of warning given beforehand allows toxic jaundice to supervene in a certain number of workers who are not withdrawn in time.

The actual signs and symptoms in particular cases will be varying combinations of those in these groups.

Physical Signs.

Evidence of gradual absorption is shown by pallor of the face and an ashen-gray color of the lips, tending to disappear if the worker becomes excited, as by medical examination. Sometimes the lips and tongue are deeply cyanosed. The tongue is generally free from fur. Abdominal distension is usually pronounced.

Jaundice may be conjunctival or general, and often appears suddenly without preliminary warning, rarely before the fourth week of employment. The liver dullness then is variable and no prognosis can be based on it, but it has been known to diminish rapidly toward the termination of a fatal case. The liver area may be tender. Ascites is present in a few cases. Respiratory distress is not noticeable when the patient lies in bed. Pyrexia has occasionally been observed in severe cases, which have eventually recovered. Neither bradycardia nor pruritus is common. Bile is present in the urine—occasionally albuminuria and intermittent glycosuria. In fatal cases coma and delirium supervene suddenly, usually about three weeks after the first appearance of jaundice.

Two deaths have occurred among T.N.T. workers from profound anæmia (unassociated with jaundice) with reduction of the red blood cells to one million per cubic millimeter. Examination of blood films showed the cells of unequal size, but there were no irregular shapes, poikilocytes, or nucleated red blood cells. Microscopical examination excluded pernicious anæmia. The symptoms in one case began with an attack resembling influenza, followed by bleeding from the nose and mouth, petechiæ on face, arms and neck, and swollen gums. In this case the characteristic atrophy of the liver was found post mortem. In the other there was no evidence in the body of the lesions which are associated with hepatic insufficiency. Death resulted from a hæmolytic aplastic anæmia, the amount of the blood-forming marrow having been greatly reduced.

Dermatitis.

Localized rashes, especially where there is pressure or friction, as from bands or ill-fitting clothes, are common. The parts most frequently affected are the hands, wrists, face (particularly round the eyes and chin), the neck and the feet. On the hands the rash is most frequently of the cheiropompholyx type; sometimes it takes the form of discrete red patches on the backs of the hands and wrists, and on the face and neck usually as a superficial erythema attended with swelling. In whatever form it appears pruritus is intense. Fine desquamation usually follows. In a few cases the skin is exfoliated in large flakes. The character of the rash is frequently altered by a secondary infection through scratching.

Speaking generally, the skin affections due to T.N.T. are not of a severe character and yield readily to the usual treatment for eczema. To allay the itching small doses of quinine have been found useful.

Differential Diagnosis.

So-called T.N.T. poisoning is apt to be confused with gastric disturbances set up by other causes. The history given by a patient is very often misleading. Many of the workers have no idea as to the nature of the substance upon which they are working, and refer to all explosive powders as T.N.T. The staining of the hands is very little guide, as this condition is met with from C.E. (tetryl or tetranitromethylanilin) and lyddite (picric acid or trinitrophenol).[1]

The following points are of importance for the diagnosis of T.N.T. poisoning:

1.—The characteristic appearance as previously described.

2.—The character and situation of the abdominal pain.

3.—The presence of constipation and abdominal distension.

Post-mortem Examination.

The outstanding feature is the atrophy of the liver, which in acute cases is reduced to one half the normal weight. The outer surface is smooth, reddish in color, with slightly elevated gamboge-colored areas of various sizes. On section in the red areas the tissue is smooth, flat and firm; the normal lobular pattern is absent, the portal systems being set very close to one another; in the elevated yellow islands the tissue is bulged and soft; an indistinct lobulation is visible, the lobules being larger than normally. Ascites is sometimes present. The bile in the gall-bladder may be unusually viscid. The kidneys on section are enlarged and icteric; the cortex bulges and the labyrinths are frequently conspicuously yellow. There is considerable engorgement of the pyramids.

The myocardium is pale, soft and flabby. Petechial and diffuse hæmorrhages are generally found beneath the endocardium, the pericardium and the peritoneum. They have been observed on the skin, on the rib cartilages, and elsewhere in the body.

Microscopical Appearance of the Liver and Kidneys.

Microscopically a great part of the liver tissue is found to have undergone complete destruction associated with a proliferation of fibrous tissue. In these areas the necrosed hepatic cells have almost entirely disappeared. The areas of complete destruction correspond to the sunken red areas seen with the naked eye. Where the destruction is not complete the histological picture is almost identical with that of the early stages of ordinary portal fibrosis. The liver tissue is traversed by fibrous trabeculæ enclosing areas of degenerate, partly destroyed parenchyma; in the healthier parenchyma slight regeneration may be present. These areas of incomplete destruction correspond to the raised gamboge-colored nodules seen with the naked eye. The kidneys show cloudy swelling and fatty degeneration in the tubules.

The jaundice is possibly the result of obstruction, because in sections of the raised areas the bile-dilated intercellular spaces have been found to be confined to the central portions of the lobules, while the portal bile-ducts have shown catarrhal degeneration and the portal ductules narrowing or obliteration of their lumina.

Predisposition.

Case incidence and proportion of deaths from toxic jaundice to attacks is little affected by sex. Thirty three per cent of recognized and notified cases have proved fatal. The fatality under eighteen years of age is striking—eight deaths out of eleven reported attacked. Duration of employment before appearance of jaundice shows remarkable uniformity, at least 83 per cent of the cases occurring between the fifth and the sixteenth week. In 105 reports on toxic jaundice not one had been employed for a period less than four weeks. Only two fatal cases have been reported where duration of employment had been more than four months, although thousands of workers have worked a much longer time. It would almost appear as though workers could be divided into two classes—the one (and much the larger) insusceptible and remaining so, however much exposed; the other susceptible and liable to succumb, especially between the fifth and fifteenth week. Although there has undoubtedly been some association between unfavorable industrial conditions and the occurrence of cases, fatal poisoning has sometimes occurred where exposure to dust and fumes at any rate appeared to be quite excluded, as, for example, in trolley work outside the building. In one remarkable case the fatal jaundice developed seven weeks after entire cessation from employment, the deceased having apparently been well during the interval. Long delay in onset of symptoms, such as is shown in this case, suggests that T.N.T. is gradually absorbed from some part of the body in which it is temporarily stored.

Channels of Absorption.

The problem of determining the chief path by which T.N.T. enters the body has been worked out in a T.N.T. factory. The T.N.T. test referred to was used in the belief that it afforded evidence of elimination after absorption, and as a sign, therefore, of the unavoidable effect of exposure merely, rather than of poisoning. Probably T.N.T., after it enters, can be eliminated from the body harmlessly in the combined form in which it occurs in the urine. Examining the urine of T.N.T. workers daily for a period of seven weeks, the conclusion come to was that where there is absorption from the skin in susceptible persons the test shows a deeper color reaction than in absorption from the digestive tract, and this reaction is found to persist for days after removal from exposure. On the other hand, the urine reaction following on ingestion of T.N.T. disappears in less than twenty-four hours. Absorption through the mouth and by breathing is probably only of less importance because when once work is over these paths of entry are no longer exposed to T.N.T., and the amount absorbed, which is less than that gaining access to the skin, is eliminated before work recommences.

Preventive Measures.

In the manufacture and use of dinitrobenzene before the war, need for minimizing the dose was well recognized either by arranging for alternation of employment or by allowing the workers such time off as was necessary for their recovery. Experience had shown that long hours of continuous work were impracticable. Similarly in some large factories where the number of workers and the nature of the processes carried on has permitted of systematic alternation of work on T.N.T. with other work away from it, no cases of toxic jaundice have been reported. And in others where on occurrence of cases alternation has been arranged the number notified has fallen. Hence, in considering remedial measures against the danger of T.N.T. in circumstances demanding the utmost output, the aim is, apart from removal of fumes and dust, to employ workers over eighteen years of age, to make suitable canteen provision, so that workers can obtain good food on factory premises, to eliminate those showing early signs by frequent medical examination, and to alternate the work or reduce the length of the shift if practicable. Complete protection of the skin is very difficult of attainment, but investigation is being made as to whether this may not perhaps be overcome in another way by the use of solvents such as have been mentioned (benzol, xylol, etc.).

The prophylactic measures adopted, for example, in the Royal Arsenal are as follows:

1.—Only persons in good health, and as far as practicable between the ages of twenty and fifty, are employed on T.N.T.

2.—All workers are inspected by a medical officer once a week.

3.—Special clothing is provided, also veils, respirators and gauntleted gloves.

4.—Employment is alternated fortnightly.

5.—Adequate ventilation in workshops is arranged for.

6.—Mechanical devices are adopted for preventing dust and getting rid of fumes.

7.—Workers are warned against sleeping in the clothing worn at the factory, and advised to have a complete change of clothing on reaching home.

8.—Facilities are provided for obtaining suitable and sufficient food at proper intervals. Milk is supplied free on the arrival of the workers.

9.—Washing of hands and face is insisted upon before meals, and before leaving the factory. Neutral soap and individual towels are provided.

Treatment.

Where jaundice is absent the treatment is simple and satisfactory. The following is the usual procedure adopted at the Royal Arsenal: Removal from contact—rest in bed for a day or two. Diet: Milk, milk puddings, fruit and green vegetables; demulcent drinks, such as barley water, the imperial drink, tea and coffee.

[1] The effects of tetryl and picric acid are both liable to be mistaken for T.N.T., and may, in consequence, lead to erroneous notification of toxic jaundice. Both stain the exposed skin—tetryl a yellow to an apricot color, picric acid a canary yellow or greenish-yellow. They both set up an acute dermatitis, tetryl affecting chiefly the conjunctivæ, the alæ nasi, the sides of the neck, the chin, and, less frequently, the hands; and picric acid the hands and forearms chiefly, very much like T.N.T. Constitutional symptoms from both are slight in comparison with those from T.N.T. No case of toxic jaundice from either has so far been reported, although thousands of workers come in contact with them. Apart from the initial dermatitis (which few handling the substance escape), symptoms of gastritis and breathlessness with diffused heart pulsation have been noted from tetryl.

For the persistent constipation vegetable laxatives and cascara sagrada are employed. A mixture containing sodium sulphate, potassium citrate and sodium bicarbonate is given as a routine measure.

In the treatment of cases with jaundice absolute rest in bed from the first is essential; milk at first in small quantities, slowly increasing the quantity given to four pints a day. The bowels must be kept loose, preferably by mist. alba repeatedly given to maintain its action if necessary.

In cases of jaundice the prognosis is always grave. Alkali-producing drugs, such as citrates and bicarbonates, are given to counteract the tendency to acid intoxication. Rectal and intravenous saline injections have a definite place in the treatment of severe cases.

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A New Condensation Hygrometer*

HYGROMETERS are instruments for measuring the humidity of air. The most convenient and the most exact are the condensation hygrometers which employ as a means of cooling the spraying of air through ether. Three types of these instruments have become classic.

The oldest, that of Regnault (Fig. 1), comprises two identical parts, each formed of a glass tube terminating at the base in a small thimble of polished silver; one of these remains empty; in the other ether is poured and air is sprayed in by means of an aspirator; each tube contains a thermometer; that of the empty tube registers the temperature of the medium; that which dips into the ether is cooled in a degree corresponding to that in which evaporation takes place; its temperature is noted at the moment when moisture begins to appear like a veil upon the surface of the shining thimble of silver. The less humid the atmosphere, the greater is the difference of temperature noted.

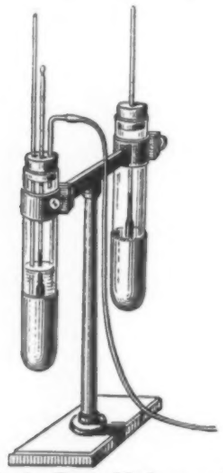


Fig. 1.—Regnault's hygrometer.

In 1878, Allvard invented a hygrometer, derived from that of Regnault, but presenting several improvements (Fig. 2). The thermometer *T'* is placed in the open air, and consequently gives indications which are more exact. The other thermometer *T* dips into a narrow brass box *D* with gilded walls, which comes into equilibrium with the interior temperature much more quickly than the Regnault tube. Finally, this box is framed by a thin metallic plate *C*, which is also gilded, without contact with the reservoir, and which facilitates, on the other hand, the observation of the slightest trace of moisture on the box *D*.

In 1883, Crova brought a new improvement to the condensation hygrometer by causing the air, hygrometric state of which is being tested, to pass into a closed envelope surrounding the surface on which the deposit of moisture is observed. In this wise one can operate on any atmosphere whatever, even that of a difficultly accessible conduit, and, above all, one avoids the evaporation of the deposit of moisture which renders results less precise when one operates in the wind, in the open air. Since this period we believe there has been no new modification in these classic apparatus.

Recently, Mr. Charles Margot has renewed the study of condensation hygrometers, and has succeeded in creating a simplified model which he has just described in the *Archives des Sciences physiques et naturelles*.

The new apparatus resembles that of Crova; like that, it comprises two closed chambers, one for evaporation, the other for observation, but both are traversed by the same air, so that only a single aspirator is required. Fig. 3 shows its structure and mode of functioning. The cooling chamber *E* is a cylinder 8 centimeters in diameter by 2 in depth. This cylinder is closed in front by a thin circular leaf of highly polished nickel-plated brass on which the moisture is deposited.

The posterior face is pierced by a small round glass window *F* which permits observation of the level attained by the ether. In front of this cylinder another chamber is fixed, which has the form of a frustum of a cone; its small base is the disk of brass of the evaporation chamber, its large base is a circular piece of glass. A thermometer *T'* dips into the cylindrical chamber, which has been previously half filled with ether. The air, inhaled by a mouthpiece or by the flow of water from a flask, leaves the hygrometer by the tube *A* after having entered it by the tube *C*.

Its passage through the apparatus is as follows: It enters the anterior chamber of observation by *C*; it issues therefrom by the tube *D*, from whence a rubber connection conducts it by way of the tube *B* to the bottom of the reservoir of ether. There the air is sprayed and evaporates the ether, and the mixture issues by the tube *A* toward the aspirator.

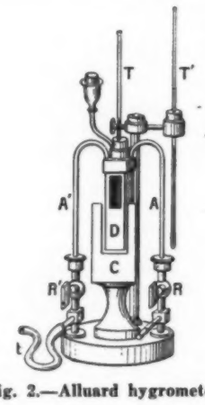


Fig. 2.—Alluard hygrometer.

The same gas, therefore, circulates throughout the whole apparatus. The observer placed in front of the glass easily perceives the deposit of moisture when it appears upon the polished disk, at whose center the condensation always commences. Controls of this apparatus have proved that it has sufficient precision for the majority of physical researches and that the circulation of air in the two chambers, whether united or separate, has no influence.

*A. Breton in *La Nature*.

Coal in Spitzbergen

THE Norwegians are showing much enterprise at present in the matter of establishing coal mining in Spitzbergen, and the prospects appear to be encouraging. The nearest markets for the Spitzbergen coal are northern Norway, Kola, Archangel, Iceland, and the Faroe Islands.

The Norwegian Spitzbergen Syndicate will have shipped some 20,000 tons of coal to Norway before navigation closes for this year, and extensive preparations are being made for the future, especially as regards the welfare of the men. For about 1 shilling 9 pence a day the men get good board and lodging, light and heat, and they all seem anxious to stay over the winter.

The Norwegian Coal Fields, Spitzbergen, another recently formed undertaking, has acquired the deposits of the Spitzbergen Coal and Trading Company. The area is of considerable extent and has been carefully examined. The deposits are calculated to contain 500,000,000 tons of coal, the quality of which has been thoroughly tested in practical use in Norway. The production is expected to reach 70,000 tons during the second year of working, and when the plant has been extended an annual production of 150,000 tons is expected.

An expedition sent from Norway during the summer to examine the area held at Green Harbor and Advent Bay by the Svalbord Coal Mining Company discovered some deposits not previously known. A portion of the same seam had indeed been found in the Hiorth coal fields on the east side of Advent Bay, but was supposed to form part of a seam already known. It now, however, appears to be an independent deposit, having a great horizontal extension in the area of the Svalbord Company southeast of Advent Bay. That company's coal fields at Advent Bay are calculated to contain 680,000,000 tons of coal, taking into account the ten seams likely to prove worth working. At Green Harbor the coal fields are estimated to contain 200,000,000 tons. Working plans are to be completed this winter on the basis of an annual output of 200,000 tons, and the erection of a plant will be proceeded with next summer.

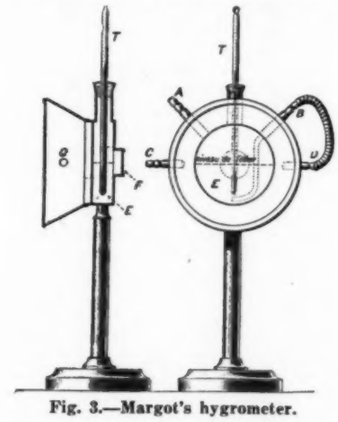


Fig. 3.—Margot's hygrometer.

—*Engineering Supplement of the London Times.*

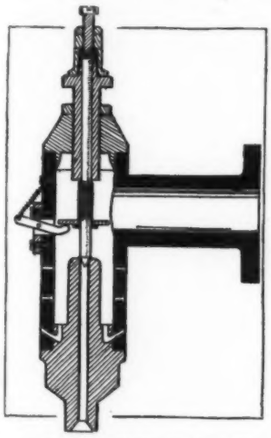
The War, the Engineer and the Politician

ENGLAND'S experience in the conduct of her military operations contains serious lessons that should be carefully studied by other countries; and some statements recently made by Mr. L. A. Legros, president of the Institution of Automobile Engineers, in London, should be given particular attention in this country. Here is a brief summary of his remarks: He said it was difficult to imagine that any engineer, unless he had been at work in a neutral country far from the seat of war, could fail to have been impressed with the appalling ignorance of technical and scientific matters among those on whom the responsibilities for running this war had fallen. Never in the history of engineering had the ignorance of science by the politicians, the military, and the other authorities been so openly displayed as in the early stages of the war, and never had it proved so costly in time, in life and in substance. How many millions and how many lives would the country have been saved if as much study in time and thought had been expended on science as on classics by the whole of our lawmakers and lawgivers? This was an engineers' war, but it was more particularly a mechanical and automobile engineers' war; yet the mechanical engineer was not a recognized factor in the army, and men of high mechanical ability and qualifications were officered by men with only ordinary military knowledge or mere administrative capacity. It was for the recognition of the mechanical engineer as a unit in the service, to be officered by men of his own profession, that the engineering institutions should agitate, preparing their case now, and postponing action till immediately after the war.

A Simple Carbureter

No portion of an automobile, or, for that matter, any internal combustion engine, is more important and interesting than the carbureter, and thousands in every land are engaged in strenuous study of the problem of supplying fuel to the engine in the proper form and proportion to secure the greatest efficiency. The results of these studies are seen in the countless devices that are introduced each year, and a noticeable feature of the majority of these devices is their complication. This is undoubtedly due to efforts toward making the carbureting device automatic under every possible condition of atmosphere and operation, particularly in the hands of unskilled operators, who must naturally constitute a very great majority of those who use motors of this class. To anyone, however, who will make a study of the variations of the barometer, even in a single locality, and also take into consideration the constantly changing character of the fuels supplied, the quest for a completely automatic carbureter, under all circumstances, can hardly fail to appear hopeless; and added to everything else is the human proclivity of "experimenting" that prevails among engine operators, and results in alterations in the delicate adjustments of these complicated devices that must horrify their designers.

Taking everything into consideration a serious question arises as to the desirability of intrusting delicately



A simple floatless carbureter.

As there is no float chamber, the supply of gasoline is controlled by a needle pressed by a spring on to the jet, which has a conical seating. A disk is attached to the needle to enable the suction of the engine to lift the needle from the jet, and as the motion increases with the speed the needle is lifted higher and more gasoline is supplied. The extreme lift of the needle is controlled by the screw at the top of the carbureter. At starting, the needle is raised by the lever on the left, which allows gasoline to flow over the jet and mix with the air admitted through a series of holes in the casing, as indicated in the drawing. A butterfly throttle (not shown) is fitted, also a Bowden extra air valve, if desired. With the addition of a hot air box around the air port good results are obtained from a fifty per cent mixture of gasoline and paraffin. It is stated that the carbureter will work equally well in any position.

contrived devices in the hands of the unskilled public; and even as to the real desirability and real effectiveness of many of the wonderful attachments found on latter-day carbureters.

A refreshing variation on the ordinary practice of adding a specially contrived attachment to the basic elements of all carbureters for the purpose of meeting each conceivable condition is seen in the accompanying sketch which illustrates a carbureter recently brought out in England. As will be seen this device consists only of a containing casing, containing a simple jet and a needle valve, to which is attached a disk that lifts and lowers in consonance with the varying suction of the engine; and an especially notable feature is the fact that there is only one adjustment provided for in the entire apparatus.

This instrument is not presented as a perfect device, but merely as a suggestion that similar simplicity might well be studied, particularly in view of the mechanical qualifications of those who use carbureters.

Size of Particles of Sand and Dust

As showing the great difference in surface area between relatively fine and coarse sands and dust, it has been calculated that a pound of sand deficient in the finer fractions contains 129,030,065 particles, having a surface area of 44.378 square feet. A finer sand was found to contain 232,075,324 particles to the pound and had 60.503 square feet of surface, while a pound of dust was found to consist of 192,715,378,500 particles, representing 527.821 square feet.—*The Engineer.*

A New Cipher Code*

WEBSTER defines a cipher as "a private alphabet, system of characters or other mode of writing, contrived for the safe transmission of secrets, also a writing in such characters." A cipher key is defined as "a key to assist in reading writings in cipher."

Some months ago, startling accounts were published in the newspapers concerning the alleged theft of one of the United States Government's secret code books by supposed emissaries of a foreign government, and, according to the newspaper stories, the possession of the missing code by possible enemies made necessary the adoption of an entirely new system for transmitting messages in cipher to and from our foreign representatives and agents.

Cipher codes are a necessary adjunct to the conduct of governmental affairs, especially in time of war, but

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	1
2	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	2
3	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	3
4	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	4
5	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	5
6	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	6
7	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	7
8	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	8
9	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	9
10	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	10
11	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	11
12	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	12
13	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	13
14	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	14
15	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	15
16	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	16
17	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	17
18	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	18
19	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	19
20	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	20
21	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	21
22	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	22
23	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	23
24	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	24
25	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	25
26	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	26
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	

Code table to be used in connection with a key word.

aside from their use by recognized government officials, the cipher message is usually thought of as the particular instrument of spies and secret agents, especially in the minds of the general public, and the very air of mystery with which cipher messages are tinged adds a fascination to any story which treats on this subject.

We have secured possession of a copy of the cipher code which we are told is now in almost general use not only by the army and navy officials of the countries at war, but also by practically all of the spies operating in Europe to-day. It consists of a simple diagram and a key word. The diagram, which is nothing more than the alphabet arranged in a simple non-secret manner, is required in the preparation and translation of messages, but is absolutely valueless unless accompanied by the key word.

A study of the following will show that the key word can be any word, sentence or combination of letters imaginable, and that the methods for reading cipher messages described so convincingly in "The Gold Bug," by Poe, and worked out by our good friend Sherlock Holmes in Conan Doyle's "Adventures of the Dancing Men," would be absolutely useless, and the chance of accidentally discovering the key word is so slight as to be negligible.

The method of preparing a cipher message by means of this code is simple. Assume we wish to send the following:

WE NEED AMMUNITION

and the key word adopted for the day was ECLUB. We write out the message and write the key word over the letters in succession as follows:

EC LUBE CLUBECLUBE
WE NEED AMMUNITION

Taking the first letter "W," refer to the diagram and look in the horizontal row beginning with "W" for the letter written above it, which, in this instance, is "E." The letter in the top line of the column with *this* "E" is "I," and this is taken as the first letter of the code message. The letter "C" is then found in the "E" row, the top letter in the column with *this* "C" being "Y," the second code letter is therefore "Y." Following the same method, the third code letter is found to be "Y," the fourth "Q," and the complete message will read:

IY YQXB CZIHRUSMNR

In order to translate the message, the same method is followed. The key word is written in succession over the message:

EC LUBE CLUBECLUBE
IY YQXB CZIHRUSMNR

Again using the diagram, look for "E" in the "I" row, and the top letter in the row with this "E" is "W." "E" is found to be the top letter over the "C" in the "Y" row; continuing this method, the entire message is easily translated.

The method of translating code messages, as described in the books of Poe, Conan Doyle, and others, is to count the different characters appearing in a long message and to assume that the one appearing most frequently was "E," which is the letter most used in our language. As can be readily seen, this would not be of assistance in translating messages written in this new code, as described above, because the same symbol in the cipher may represent entirely different letters in the message itself. For example, "E" in the message is represented by "Y," "Q" and "X," and "M," which occurs twice in succession in the original message, is represented by "Z" and "I" in the cipher.

The publication of this cipher code will no doubt bring to the mind of the reader other codes, but it is doubted if any heretofore invented is as effective in every way as is this one.

The method used for the preparation and reading of code messages is simple in the extreme and at the same time impossible of translation unless the key word is known. The ease with which the key may be changed is another point in favor of the adoption of this code by those desiring to transmit important messages without the slightest danger of their messages being read by political or business rivals, etc.

*Proceedings of the Engineers' Club of Philadelphia.

Casehardening Bronze for Dies

THE bronzes which possess the greatest hardness lack the requisite properties for chasing and sinking fine intricate designs. It is, however, possible to obtain a hard face on a bronze by a process analogous to the casehardening of steel, and this is practiced with some bronze dies. The method is that of coating the surface of the die with pure tin, and then heating to a low red heat in order to alloy the tin with the surface of the bronze. As is well known, copper and tin unite in all proportions, and with from 20 to 30 per cent of tin the alloy becomes quite hard.

The surface of the die to be casehardened is cleansed from grease by soaking in a strong hot potash solution and then immersing in a pickle or dip of acid to remove the oxide. A suitable pickle, which works more rapidly if hot, is made with five parts of water and one part oil of vitriol, and the die is allowed to soak in it for several hours until clean. It is then taken out and brushed, and the surface coated with a strong solution of chloride of zinc to act as a flux.

The surface is then covered with pure melted tin. The tin may be melted on the surface by a soldering-iron, but by far the best method is to use a torch or a blowpipe. The tin is melted over the surface only, and as little as possible put on, as the fine detail of the die must not be filled up. The die is then washed in water to remove the excess of chloride of zinc flux, and the surface examined. If there are any portions which are not covered with tin the process is repeated.

The next operation is to heat the die to a red heat, preferably in a muffle, though a blowpipe or a torch may be used. To prevent the surface from oxidizing, it is advisable first to cover it with a strong solution of boracic acid. The boracic acid is dissolved in hot water and the solution lightly brushed over the surface. A light coat only is necessary. The die is placed on an iron plate to keep it from breaking when heated, as tin-bronze becomes brittle at a red heat, and it is heated to a low red heat and allowed to remain in this condition for ten or fifteen minutes. The plate is then removed from the muffle and the die allowed to cool. The boracic acid is removed by soaking in hot water and afterward pickling, if necessary. After the foregoing operations, the surface of the bronze is quite hard and difficult to cut with a file.

Dies hardened by this method can be used for stamping leather, soft metals, paper, and similar work, as they can be made originally soft enough for chasing or sinking with ease, and then hardened without destroying the design. The best results are obtained by using a rather soft bronze mixture with as little lead as possible. Such a bronze, high in copper, is not likely to give trouble by softening or cracking during the heating. A mixture recommended for this work is: Copper, 88 pounds; tin, 8 pounds; zinc, 2 pounds and lead, 2 pounds.—*Foundry Trade Journal.*

Vibrations, Waves and Resonance—II*

The General Principles Underlying Wave Motions

By J. Erskine-Murray, D.Sc., F.R.S.E., M.I.E.E.

Continued from Scientific American Supplement No. 2142, page 35, January 20, 1917

WAVES IN PONDERABLE MATTER.

When we met last week I pointed out to you that if I could make a vortex ring vibrate sufficiently rapidly you would hear a musical sound. Now it is possible that this is actually realized in the flight of a bullet or shell. You have, no doubt, seen Mr. Boys's beautiful photographs of a flying bullet, and have noticed that, in addition to the compression waves which slope out from it like the bow waves of a ship, there are many small vortices in its wake. It is quite likely that these may be in sufficiently rapid vibration to act as sources of sound waves, and thus to add to the sound produced by the compression waves.

To-day we tackle the subject of waves in ordinary matter; such waves, for instance, as those of the sea, of clouds in the sky, and of sound. I shall not attempt to deal with breakers, in which the water at the top of the wave actually runs continuously forward in the direction of the wave motion, but shall stick to periodic motions such as those of waves in deeper water or of sound in air or other materials.

The first great thing to notice about a wave is that, though the wave travels steadily forward, any given particle of the material in which it is traveling merely executes a to-and-fro motion. A wave is, therefore, the forward motion of a vibration, but not the forward motion of matter. It is, in fact, the motion of a motion. There are two principal kinds of waves, the transverse and the longitudinal, these names being given from the direction of the vibration of the medium. In the transverse wave the motion of the material is to and fro at right angles to the direction of motion of the wave. Here, for instance, I have a long strip of corrugated paper lying on the table. I lift one end quickly and bring it down again: a wave runs right along to the far end. Quite obviously the paper does not travel with the wave; it merely rises and falls again at points successively farther and farther from my hand. The wave travels on, however, and is quite as clearly a wave as any other you like to name. Here, again, is a rope stretching from one end of the hall to the other. I give it a transverse impulse by striking it sideways near one end, and you see the wave running along it to the opposite wall, where it is reflected and comes back to me.

In a wave of the sea, i. e., a surface wave in a liquid, the vibration is also transverse, that is to say, any particular particle of water moves up and down as the wave passes along. You all know from experience that a cork on water merely bobs up and down and does not travel forward with the wave. If the water went forward, of course, the cork would go too.

Perhaps the simplest way to understand the motion of a water is to study the comparatively simple type produced by dropping a stone into a calm pond. In these diagrams, lent me by Prof. Silvanus Thompson, we see the progress of the motion. First, the stone strikes the water, pushing it out all round, and, as water is nearly incompressible, the water near the stone has to *rise* to make room for the stone. It cannot go down—there is water there already; it cannot go far sideways because of the inertia of all the water in front of it; so on the whole it must go up. Having risen in a ring all round the stone it is now in an unstable position; there is no permanent force to hold it up, so it falls. In so doing it pushes up the water just outside it, and this in turn falls and pushes up the water farther out. There is thus produced a ring of raised water of constantly increasing diameter, and this is the circular wave which you see traveling outward in all directions from the point at which the stone fell into the pond. With the exception of a small outward movement in the water close to the stone, the motion of each particle of water as the wave passes is up and down in a narrow ellipse which nearly approximates to a vertical line. The smaller waves which follow the first as a series of concentric rings are due to the inertia of water. Just as in the other vibrations which you have seen, the water raised by the stone does not come to rest when it first reaches the general level of the surface, but goes on in a downward direction, thus making a circular wave of depression which follows the raised ring, and at the same time raises a central peak in the water behind it where the stone fell through the surface. This peak in turn falls down and starts a second raised ring, and the action goes on repeating until the energy of the stone's impact on the water has been used up in producing the waves, and till finally these die out through molecular friction and this energy is turned into heat.

The production of waves by a ship as it is driven through the water is a similar phenomenon. As the wedge-shaped bows of the ship press the water outwards it rises, and in falling propagates a wave which travels outward, just as in the case of the stone dropped into water, but with the difference that the source from which the waves start is moving rapidly; indeed, more rapidly than the waves themselves. Hence the exquisite retreating curves in which the waves spread out on either side of the ship. You can see something of them in the photograph, taken by Mr. Vaughan Cornish, which is thrown on the screen; but it is far better to watch them for yourselves from a height overlooking some calm waterway where ships go to and fro. Why, even London Bridge will do!

There is an interesting case of ship waves which you may have noticed, that of the tramp steamer ploughing her way down Channel with a great foaming wave right across her bluff bows—a "bone in her mouth," as seamen call it. Here the speed of the ship is no greater than that of the wave produced, and instead of curving away like an arrowhead the wave stretches out on both sides, nearly at right angles to her course. In this it is like the stern wave of all vessels, which, rising under the stern, spreads out and settles down after the ship has passed into nearly a straight line.

In this other picture you see a similar type of wave, produced this time by the flow of water over a ridge of shingle. It is the lower end of Loch Lubnaig, in Perthshire, where the stream runs out. The quiet water of the loch flows toward the gravel beaches as they converge to form the banks of the stream, and underneath the surface the spits of shingle are like two ploughs with water flowing past them. You see the waves produced by each are just like those of a steamer, though in this case it is the water that moves and the vessel that is at rest. Such waves as these are seen above a moving submarine, even when it is traveling far below the surface.

The generation of waves by wind is not so simple, though what is produced is, as before, merely an up-and-down motion of every drop of the ocean. But there is this difference, that the longer and harder the wind blows and the farther the wave goes, the more the motion grows. Let us see how it starts. In the first place, when one fluid—air—is moving over the smooth surface of another fluid—water—the motion is unstable, and for the following reason. The smallest extra downward pressure of air on a patch of water will cause a slight hollow and, of course, a little rise in front. As the air travels up the rise it will shoot over the top, and just behind the crest there will be a partial vacuum, very slight, but sufficient to encourage the crest to rise a little higher. Thus every time the water rises in its place it will be to a little greater height, and everywhere the up-and-down motion will increase. The result of this will be that each wave which travels off down wind from the initial place of vibration will be larger than the one before, and that the farther the wave goes the larger will it become, for at any position its energy is that of a vibration which has grown in amplitude from two causes: first, by superposition of the waves coming down wind to its position; and, second, by the action of the wind in its own locality. In the photograph of the Luss Straits on Loch Lomond, which you see on the screen, this growth of the waves under the action of the wind is very obvious. On the left the waves are small, but down wind toward the right they grow both higher and longer from crest to crest as they go.

The explanation I have given you of the growth of waves at sea has not, as far as I am aware, been put so fully in words before, although there is a suggestion of it in a paper of Lord Kelvin's. It accounts for the more obvious phenomena of sea waves and also throws light on some of those less commonly noticed I have, for instance, observed the following in watching a rough sea. All the large waves come toward one in a comparatively regular succession and with practically the same speed. If, however, one notes that a certain wave is larger than the others and watches it one finds that, although it travels in the procession as a wave, it only continues to be unusually large for a very short time; in fact, it loses its characteristic size as it travels, and the wave behind it in turn becomes a large one. The maximum vibration thus travels forward much more slowly than the individual waves. This is a curious observation. It does not mean that a long wave, i. e., one which is long from crest to crest, travels more slowly than a short one, for the reverse is true except for small ripples, but that in a series of waves, all of nearly the same length, a wave which is particularly high at one place does not continue to be a high one throughout the whole of its course, but leaves its height behind it as it progresses. That is to say, the place of maximum vibration lags behind the actual wave motion. Since the velocity of a wave increases as the latter becomes longer in traveling down wind, the probable explanation of this phenomenon is that the extra height is due to the superposition of the two wave trains of slightly different wave length, and therefore traveling with different velocities. Their crests will thus coincide and give maximum waves at certain points which travel forward with a velocity less than that of even the smaller waves. This type of phenomenon, due to the difference in the velocities of waves of different length, does not appear to have attracted the attention it deserves, perhaps on account of the fact that in certain media all waves appear to travel with the same velocity.

When the difference in wave length is great, as, for instance, in ordinary sea waves with a ground swell coming in, where each of the longer waves is many times the length of the others, there is a somewhat different effect. Atlantic waves are sometimes considerably over a thousand yards between one crest and the next, and as these come in at about one per half minute the result is more like a tide than a wave. Apparently the whole sea rises with all the smaller waves on its surface and sinks again. Sitting on the rocks at the mouth of Pornic Cove, in Brittany, I have watched a tide which ebbed and flowed once in every five minutes. The rise and fall totaled about a couple of feet and was quite regular and definite. Two explanations are possible. Either it was an immensely long Atlantic swell coming in, or, what was perhaps more likely, it was the natural vibration of the water in the cove—a deep and narrow harbor running about a mile into the land. Many cases are known of such vibrations of large masses of water: in the Scottish lochs, for instance, they are continually occurring, being started by differences of wind pressure on opposite ends or sides of the lake. A very careful survey of these motions, and of their relations to the depths and forms of the lochs in which they happen, has been made, the results being published in the *Proceedings* of the Royal Society of Edinburgh. The technical name for such a little tide is the French word *"seiche,"* the having been first observed in the lake of Geneva. The common saying that the seventh wave is always the greatest is probably a recognition of the fact that there is usually on all sea coasts a swell of great length in addition to the smaller waves of more local growth.

I shall now show you a simple experiment which illustrates very clearly some of the more important laws of wave motion. Here is a large photographic tray in which there is some water mixed with a considerable proportion of syrup to make its movements slower, so that they may be more easily followed by the eye. I place an arc lamp near it, the light of which is reflected from the water surface and thrown upward on the screen as an oblong patch. You will see that the slightest disturbance causes a ripple in the water, which travels across the tray and is reflected from the other side. If I touch the surface with a small stick, or let a drop of water fall on it, a rapidly growing ring of concentric ripples travels outward till it touches the side and then is reflected back. Notice that the reflected ripples cross the band of incom-

*Cantor Lectures before the Royal Society of Arts. Republished from the *Journal* of the society.

ones without stopping their motion or being in the least distorted themselves, and in fact that each wave travels onward just as clearly and independently across the others as it would do on a calm surface. You can see clearly that when a band of ripples crosses another band and arrives again in a calm surface, it is quite evident that it has suffered no distortion in the process. The essence of this observation is that waves do not destroy or even confuse one another, but that each goes on its own appointed course as if none other existed. Thus it is that we can hear sounds from many sources at once and distinguish them, and that the ground swell does not obliterate the cross sea on its surface.

I may now state this as a law of wave motion: Any number of wave motions may co-exist independently in any medium without mutual distortion, and the motion of any portion of the medium is simply the result of the superposition of the waves passing through it.

If I strike the table with my hand you see straight bands of waves starting simultaneously from all sides of the tray. They travel forward, making a tartan pattern, and, crossing one another at the center of the dish, arrive at the sides opposite those from which they started quite unchanged. If, instead of giving a single stroke, I continue to beat the table at short intervals, the tray becomes full of these waves, and the result is a fine chequered pattern of bright points and dark lines covering its whole surface. These appear to be merely rising and falling at fixed points, and for this reason are sometimes called stationary waves; but the moment I stop beating the table, you see that they are really just the points where several sets of traveling waves cross one another. One can see an effect like this wherever waves cross one another, and very clearly near a sea wall or stone pier. The reflected waves travel back through the incoming ones, and where two crests meet the compound wave rises to a great height, often breaking into spray. A "jabble" is the technical name, and well describes the apparent wildness and irregularity.

The same effect can be seen in the long stretched rope if I give it a second impulse just as the first has reached the far end. The two then meet in the middle, and, as the reflected one is returning on the other side from which it went out, apparently cancel one another at this point, but pass on nevertheless. By repeatedly striking the rope at intervals, each equal to the time taken by a wave to travel from one end to the other, I can keep this motion going, and the string continues to vibrate in two sections with a quiet spot at its center.

The speed of a deep-sea wave is proportional to the square root of its length from crest to crest; but in shallow water another rule holds good. If you watch a long swell coming in from deep water over a slowly shelving bottom you will see that the distance between crests is gradually reduced, showing that the speed of a wave in shallow water is less than in deep. The case of waves in a canal is an especially interesting one, and has been calculated by Lord Kelvin. He found that there is a limiting velocity faster than which a wave will not go. This is illustrated very neatly by the way in which the passenger boats used to be run on the canals in Scotland. These were light and shallow vessels, not like the great barges now used for freight-carrying, and were drawn by a pair of horses. At first their speed was that of a walking horse, say four miles an hour, and at this rate they traveled with a large wave always just in front, and it was hard work for the horses. One day the horses bolted, the barge was jerked forward over the top of the wave, and, to the surprise of the driver, continued to move forward quite easily at about ten miles an hour without creating any wave. After this the obvious method of whipping up the team at the start and then keeping them at a steady trot was always adopted. The fact was that they were now going as fast or faster than the most rapid wave possible on the canal. Thus no wave was produced, and no energy to speak of was wasted in churning up the water.

A type of wave which I have not hitherto mentioned is the ripple, by which I mean the little waves less than an inch from crest to crest, which do not mainly depend on gravitational force, but are controlled chiefly by the molecular attractions between adjacent molecules of the liquid. The effect called surface tension is produced by these forces, and its result is as if the surface were a solid elastic sheet. The speed of a ripple, unlike that of a larger wave, is greater as the length is less, a fact very easily observed in water. Here I must remind you that all the water waves with which we have dealt are surface waves in fact, and for this reason are more complicated than internal waves, such as sound waves in air, or electric waves in a large mass of dielectric. There are, of course, surface phenomena in all wave motions at the interface between two media, but in sound and electricity the internal waves exist and are important, while the only truly internal waves in water are either sound or electric, for the ordinary waves are solely due to the fact that above the water there is the air, a fluid of much less density.

Even in the atmosphere itself surface waves are possible, for there are sometimes sharply marked layers of different density. Here is a photograph which shows you a series of long straight clouds lying in parallel lines, just like the crests of a swell. Such, indeed, they are, being the tops of great air waves in which the moisture has become condensed as they rise, thus rendering them visible; they indicate that in the upper layer the air is blowing across the air beneath it, just as the lower air blows across the sea; but they travel slowly, for the difference of density of the two layers is small, and on this depends their speed. In another of these pictures we see, from above, a wonderful sea of clouds, which at first sight appear to be piled at random away to the farthest horizon; but on closer examination an order is evident, and many parallel ridges are clearly discernible. Now, when a fluid surface shows such a definite formation one seeks an explanation, and in this case that of wave motion is the only one which fits. Indeed, whenever a fluid shows a structure in parallel lines the presumption is in favor of a wave motion being the cause.

There is one great set of waves, so large that we do not recognize them as such, which is of the utmost importance to us as an insular people—I mean the tides. If the globe were covered to a uniform depth with an endless sea the tide would be quite a simple motion; but as it is, with the ocean broken up by continents and its depth varying from several miles to a few score feet, it becomes a most complex procession of waves whose periods can only be determined by prolonged observation. But once determined and analyzed into their simple harmonic components they can be predicted for years ahead. This sounds remarkable, but really the process is quite simple. First one determines the component simple vibrations by graphical or mechanical analysis of the record of past tides at the station. Then one adjusts each of the vibrators of the tide-predicting machine to represent by its motion one of these component vibrations, and thus the end of the cord, which passes over all the vibrators, performs a complex vibration, and records the form, height and period of the tide required on a moving strip of paper. The tide predictor is a frame in which are set two horizontal rows of pulleys. A cord, fixed at one end and free at the other, passes over an upper pulley, then under a lower one, and so on up and down across the board. At its farther end is a weight with a pen attached. Each pulley can move up and down in a vertical guide, and is made to do so at a properly chosen rate by gearing behind the frame. Hence, as each pulley moves it lengthens or shortens the bight of cord which is round it, and alternately raises or lowers the weighted pen at the free end of the cord. As all of the pulleys are working on the cord at once, the movement of the pen is simply the sum of their separate motions.

I have constructed a simple machine which will show you this composition of harmonic motions, though in this case the vibrations are damped and not uniform, like those of the tide predictor. It consists of two weights hung on helical springs, which are attached by their upper ends to the top bar of a trestle. A horizontal rod is connected by flexible couplings to both the weights; it runs, in fact, through the rings on them, and is held in position by fine cords. One end of the rod projects beyond the weights, and has a small paint-brush fixed across it horizontally. If I now set the weights in vertical vibration the paint-brush performs a complex up-and-down motion which is compounded of the separate vibrations of the weights, and by drawing a sheet of thick paper steadily past the brush I obtain on it a wavy line giving the form of the compound vibration. Also, by keeping either weight still and letting the other vibrate alone, I get its wave form: so here you have the records, not only of the compound vibration, but also of each of its simple harmonic components. By hanging additional weights on one of the vibrators you see that I obtain another form of record, and that if the frequencies of the vibrations are not greatly different the motion is a curiously complex one. To find how long it will be until the record begins to repeat itself is really a problem in our old school friend the L.C.M., so that hackneyed rule is of use after all; I say to repeat itself, though with this machine this is hardly exact, since as the vibrations are continually dying away they never are repeated in size, although they are in form.

The model, lent me by Prof. Thompson, which I now show you demonstrates a very curious type of vibration. As I move it you see that each of the knobs at the top of the rods describes a nearly circular curve in a plane perpendicular to the wave, and that the wave travels forward with a cork-screw motion. In this other model, which consists of a ladder of tape with knitting-needles as rungs, we get what at first sight appears to be a similar wave form; but it is not so, for in this case the ends of the needles reverse their motion and rotate to and fro, whereas the knobs in the first model moved continuously round in circles. The second model shows torsional waves such as are easily produced in rods or masses of elastic material, and are, in fact, of very great importance in propeller shafts and other structures. I have seen them, for instance, in a long corridor carriage traveling at high speed on one of our main lines when looking along the corridor from one end to the other.

From the experiments which you have now seen you will realize that the vibrations which generate a transverse wave may be either in straight lines at right angles to the direction of the wave motion, or in curves of any form in planes at right angles to the same. When we have stated the character of the vibration we have defined the property of the wave which is termed its polarization.

All the waves which we have considered thus far are transverse in nature, and among those of this class are also included the waves which we know as electric and as light and heat. There is a smaller but still very important class, in which the motion of the material through which the wave passes is to and fro in the direction of the wave itself. These are called longitudinal waves, and are only found where the medium is compressible either on account of its nature or because the wave is merely carried along a rod which is free to expand or contract in lateral directions, since it is surrounded either by a compressible or by a fluid material. I shall show you examples of both types of longitudinal wave, and, as it is perhaps the simplest to demonstrate, I shall commence with a longitudinal wave on a long rod or cord of elastic material surrounded by air, which, by the way, is both fluid and compressible.

Here I have a long thread of india rubber, on which I have strung at equal intervals a number of small leaden weights in order that the wave may be slowed down so as to be visible by you. To keep the india rubber in a straight line, it is supported from a horizontal bar above it by a number of cotton threads; these do not appreciably interfere with or alter the wave motion which I am going to show you. At one end of the rubber a small lever and flag are attached so that those of you who are not close at hand may see the arrival of a wave more easily. I now pull and suddenly release the near end of the rubber cord. You see the impulse running along it made visible by the crowding of the little leaden weights. This crowding, which is in fact a compression wave, runs along to the far end and wags the flag. Keeping your eye on any one of the leaden beads, you see that it merely moves to and fro lengthwise as the wave passes. The wave is thus truly longitudinal, the vibration of any particle being forward and backward in the direction of the propagation of the wave. If you watch closely, you will see that the wave is reflected from the far end and returns to my hand just as in the case of the transverse wave on the long rope, and if I give the cord a succession of little tugs at proper intervals I can produce stationary waves with a quiet spot half-way along the india rubber in the same way as with the rope.

I have said that I loaded the rubber thread with leaden weights in order that the wave might travel more slowly. It is quite easy to show you that adding inertia does retard a wave. This piece of cord, about 30 feet long, is loaded for 10 feet of its length at the end farthest from me. If now I start a series of waves so that the cord gets into stationary vibration, you see that, while there are two vibrating segments in the loaded portion of 10 feet, the whole 20 feet of unloaded cord vibrates as one. Now the length of a segment, i.e., the distance between one node and the next, is inversely proportional to the velocity of the wave running along it, for the times in every case are the same, and also the number of impulses per second. Hence since the unloaded segment is four times as long as one of the loaded ones, the velocity of the wave in the unloaded part is four times that in the loaded portion. To make this more evident, suppose we cut 5 feet off the loaded section of our cord. The cord would then be 25 feet long and there would only be one node, i. e., at the commencement of the loaded section, in addition to the fixed points at the ends. Now imagine two impulses starting simultaneously in opposite directions for this node, and traveling to the ends of the cord and back

again. Clearly, if the node is to remain a node, i. e., a quiet point, the two impulses must again pass simultaneously through the point from which they started. Hence the time taken by an impulse to travel over each segment of the cord must be the same, and, as the unloaded segment is four times as long as the loaded one, the velocity in it must be four times as great. Loading the medium along which a wave passes, therefore, slows its progress. We understand why this is so when we reflect that the rapidity of a wave's motion depends on the rate of the local vibrations which constitute it, and that these are slower the greater the inertia of the vibrating body. The same is, of course, true whether the vibrations be transverse or longitudinal.

I shall now show you by a simple method, which I discovered some years ago, the movement of a sound wave in air. On the table a yard or more away from me I place a lighted candle. Standing facing the candle, I hold a piece of stiff cardboard about 1 foot square in both hands in front of me. If now I suddenly pull the cardboard toward me, you see that the flame is momentarily drawn over toward the retreating card. I place a second candle a foot or two beyond the first and repeat the experiment. Now both flames move with the motion of the card and, as nearly as can be judged, at the same moment. Clearly, therefore, the rate at which the disturbance travels through the air is high, certainly more than one hundred feet per second, for if it were slower the eye could notice that the near candle flickered before the farther one. The disturbance cannot, therefore, be a draught of air in the ordinary sense; that is to say, it is not caused by air actually flowing across the room. What happens is this. Jerking the card toward me leaves a partial vacuum behind it, since the neighboring air cannot instantly flow in because of its inertia. The air against the card is, therefore, momentarily rarefied. Into this partial vacuum the air immediately beyond it commences to fall, becoming itself rarefied in the process. Then the air immediately beyond this falls in, and so the rarefaction travels on until, on reaching the candle flame, this falls in also and shows you the presence of the wave. A very similar action is visible in a large heap of sand or fine gravel when a spadeful is taken out of one side of it. The sand commences at once to fall into the vacancy, and the falling-in process keeps on spreading farther and farther until an equilibrium is reached.

I have called this a sound wave, as in fact it is, although your ears are not sensitive enough to hear it. If I could move the card more rapidly, and thus produce a better vacuum, you would hear a single thud, owing to the outward motion of the drums of your ears as the rarefaction came along to them.

If, instead of pulling the card toward me, I push it suddenly away, I produce a compression wave which travels exactly as does the rarefaction. It is not so easy to show you, however, as one's muscles are not so well suited for a sudden push as for a pull. Probably the greatest wave of this kind on record was that given out by the volcano of Krakatoa. I have already mentioned how it was heard as a loud sound after traveling fifteen hundred miles, and was detected by sensitive barometers after it had gone one hundred and forty-four thousand miles, i. e., six times round the globe.

Another interesting case of sound transmission is the submarine bell. In water, on account of its very small compressibility, a sound wave travels about four times as fast as it does in air, and, when once started, it has considerable energy owing to the density of the water. The result is that under water it is no uncommon thing to hear a submarine bell at a distance of sixteen miles, and the more powerful sound of the Fessenden hooter has been heard at fifty-five miles off. The latter is something like an electric motor-car hooter on a very large scale. A steel disk is caused to vibrate rapidly by an electro-magnet carrying an alternating current; it produces a succession of waves of compression and rarefaction in the water, and these are appreciated as a tone in a telephone connected to a microphone which is immersed in the sea. Submarine bells are now very largely used in navigation in all parts of the world, but especially on the eastern coasts of America, where scores of them are located on sunken shoals and as guiding points near the entrances to harbors. Most transatlantic liners are fitted with the receiving apparatus, which consists of a pair of microphones, each enclosed in a box full of water fixed against the plating of the vessel *inside*, on either bow. If the ship is heading straight for the bell the sounds picked up by the microphones are equal in strength: thus the bearing of the bell can be determined and the proper course set. In thick and foggy weather the bells have proved to be of the greatest use.

(To be continued.)

The Importance of Impurities

At a recent meeting of the New York Section of the Society of Chemical Industry, Mr. Jerome Alexander brought out some very interesting information on the importance of impurities and he referred to a number of interesting examples in which at one time or another impurities have been found to help and again to hinder achievement.

His first example was one more or less well known to chemists of the troubles of Count Auer von Welsbach in making his Welsbach gas mantle. He wanted to make it of thoria, which is the oxide of a metal found in the rare earths, in the monazite sands of North Carolina, for instance. He had a good gas mantle and then again he didn't have it, and as he worked along on his problem, the purer he got his thoria the worse his mantles were.

Now there is another metal found in the rare earths called cerium and the oxide of this is ceria. It is much more abundant than thoria and as the Count was trying all the time to get rid of the ceria, his troubles increased. Ceria would not do for gas mantles; he had tried that out before. So, as his mantles grew dim, he saw a light and began to try mixtures. Pure thoria was no good, neither was ceria, nor a mixture of half in half. But just five per cent of ceria gives the brilliant light. With either a little more or a little less it grows dim.

In the iron and steel industry the trickiness of minute quantities of foreign bodies is so well recognized that specifications are often made limiting them to the third decimal place.

In making ammonia by the Haber process practised in Germany, by bringing nitrogen and hydrogen together in the presence of certain metals, the whole thing is spoiled if there is any sulphur, selenium, tellurium, phosphorus, arsenic, boron or any of their compounds present. Lead, bismuth and tin will also kill the process. As low as one part per million of sulphur in the hydrogen gas works serious injury.

In making sulphonal, the well known sleep medicine, there is produced a mercaptan that has such power of vile smell that one four hundred millionth part of a milligramme may be detected. A gramme is about fifteen and one half grains troy, or, say, three and one half hundredths of an ounce. A milligramme is a thousandth part of this. So it just will not do to let any of that mercaptan get into the medicine. Not even the least little bit!

In making white lead by the Dutch process, if there is no more than one hundredth of one per cent of silver in the lead from which it is made, it will come out pink. If the lead contains two hundredths of one per cent of copper it will have a green tinge.

A very little lead in brass makes it machine well, but in gold, one part of lead in 5,000 makes it very brittle. In gold plating (electroplating) a very little copper gives a red shade and a very little silver gives a greenish color to it.

In dry batteries traces of iron in the manganese oxide or copper in the salammoniac are very undesirable. Traces of arsenic in the hydrogen used by lead burners prevent a good joint from forming. One part per million of sulphur in cocoanut oil spoils the soap made from it. In making tests on a certain plant it was found that one part of manganese in 10,000,000 greatly increased its growth and one part of silver nitrate in 1,600,000 killed it. Although silver is practically insoluble, the plant immediately died if planted in a silver cup.

In conclusion Dr. Alexander spoke of how we have smiled at the Chinese medicine man who prescribed toads and caterpillars and reminded us that toads had formed the basis of a folk remedy among American colonists. Then he quoted from Prof. John H. Abel in *Science* to the effect that he had isolated adrenalin from the skin of a tropical toad, and also a crystaline substance to which he says the skin owes its curative power in dropsy. That is one on most of us. It is almost gruesome how many superstitions contain a lost fact.

Oil Cake in France

As Messrs. A. Gouin and P. Andouard point out, the matter of using oil cake for stock feeding has not received the attention that should be given to it as concerns France, for this country produces oil cake in large quantities from its extensive oil industries. That the output is a large one will be seen from the fact that the annual production for Marseilles alone averages 300,000 tons, of which peanut oil cake (arachide) forms two thirds. In other industrial centers such as Bordeaux and Paris the output amounts to a large figure. In normal periods the Marseilles output corresponds to 200,000 tons of nutritive matter, and this would correspond to 28,000 tons weight in the shape of stock. By an improved method of feeding, this amount could be raised to 36,000 tons. Since this country is now importing cold storage meat, such an addition to the home supply would be most timely, and no extra hand labor would be needed. The use of oil cake would mean quite an increase in the milk production as well. On the other hand, oats for horses—a high-priced food now—could be replaced by peanut or palm oil cake to a large extent. Poultry raising would also profit by it. Hence the authors point out that measures should be taken at once to make use of this material.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANUARY 27th, 1917.

Published Weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer;
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

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The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (Established 1845) . . . . " 4.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

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